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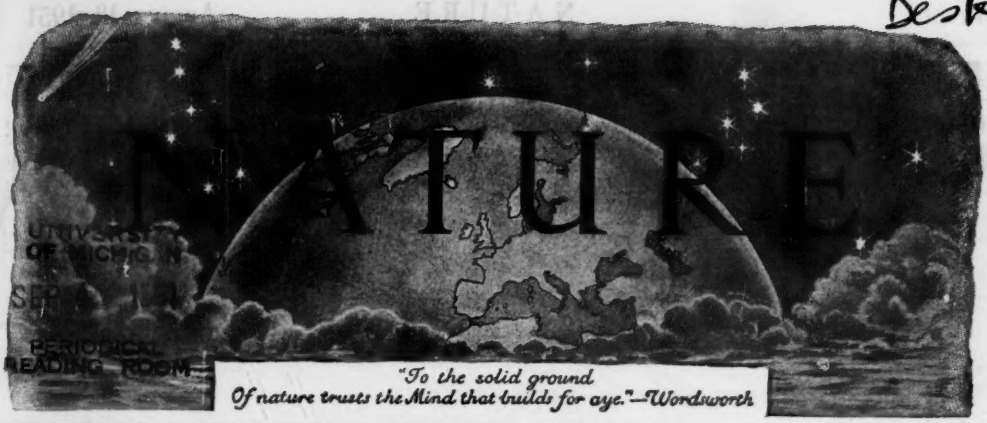

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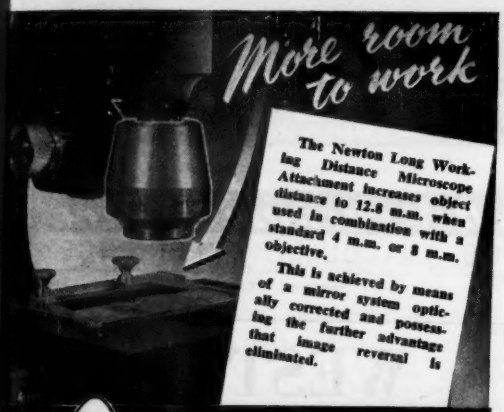
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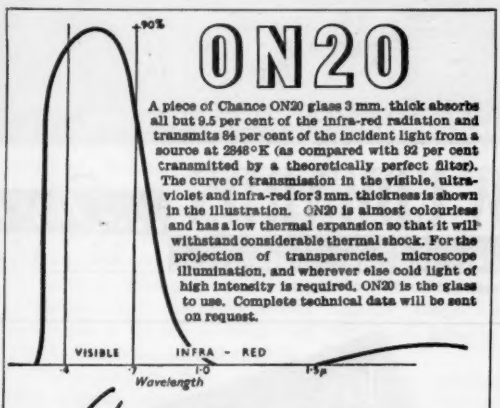

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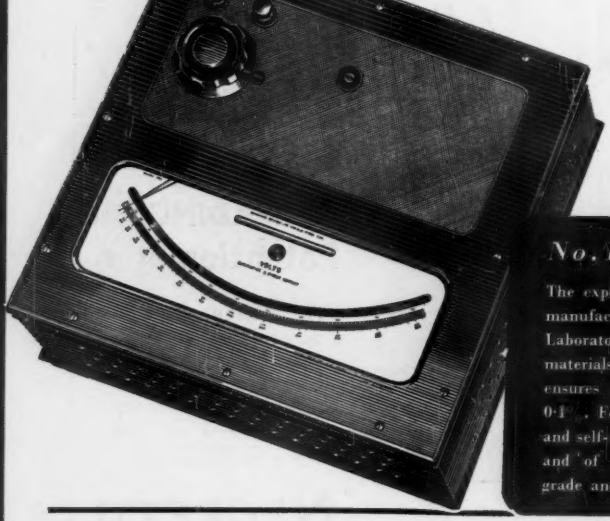

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NATURE

No. 4268 SATURDAY, AUGUST 18, 1951 Vol. 168

CONTENTS

	Page
Biology in Education	257
The Beginning of the Universe. By Prof. T. G. Cowling, F.R.S.	259
Measure and Measurable Functions. By Prof. H. T. H. Piaggio	260
Life in the Gran Chaco. By Prof. James Ritchie, C.B.E.	260
Taxonomy of *Penicillium*. By G. Smith	261
Acoustics of the Royal Festival Hall, London. By P. H. Parkin	264
Relationship between Hæmoglobin and Erythrocruorin. By Prof. D. Keilin, F.R.S., and Dr. E. F. Hartree	266
The Cosmic Ray Observatory at Ottawa. By Dr. D. C. Rose	269
Determination of the Absolute Configuration of Optically Active Compounds by means of X-Rays. By Prof. J. M. Bijvoet, A. F. Peerdeman and A. J. van Bommel	271
Breeding Ground of Pilchards off the Coast of South-West Africa. By Dr. T. J. Hart and N. B. Marshall	272
News and Views	273
Thermal Conductivity of Dielectric Crystals: the 'Umklapp' Process. By Dr. R. Berman, Prof. F. E. Simon, C.B.E., F.R.S., and Dr. J. Wilks	277
Theoretical Aspects of Superconductivity. By Prof. H. Fröhlich, F.R.S.; M. J. Buckingham	280
A Method for making Accurately Reproducible Masks of the Huggins Type. By Barton Howell, Carl J. Christensen and Dan McLachlan, jun.	282
Applied Electronics. By C. A. Taylor	283
Research and Development in the Simon Engineering Group. By Dr. W. Rheinallt Thomas	284
Factors concerned in Fertility of Mammals	286
Indian Veterinary Research Institute: Diamond Jubilee Celebrations. By Dr. G. Lapage	287
Letters to the Editors:	
Relative Abundances of Oxygen and Carbon Isotopes in Carbonate Rocks.—Dr. P. Baertschi	288
Preparation of Uniform Solid Samples for Radioactive Assay.—Dr. M. L. Wright	289
Inelastic Scattering of Cold Neutrons.—P. A. Egelstaff	290
A New Method of Observing Compton and Other Incoherent X-Ray Scattering in Crystals.—H. J. Grenville-Wells	291
Intensity Variation in Sunspots.—Dr. R. Ananthakrishnan	291
Effects of Ultrasonic Irradiation on the Coagulation of Cellulosic Solutions (Viscose).—Dr. V. Tomberg	292
Spectral Reflexion Factor of the Cat's Tapetum.—R. Gunter, H. G. W. Harding and Dr. W. S. Stiles, O.B.E.	293
Estimation of Volatile Fatty Acids and Ammonia in Silage by means of Paper Chromatography.—Prof. Artturi I. Virtanen and Jorma K. Miettinen	294
A Phosphate Ester of a Tricarboxylic Acid in Liver.—S. Rapoport and Robert H. Wagner	295
Dietary Origin of Urinary Methyl-Histidine.—S. P. Datta and H. Harris	296
Kidney Citrate Levels in Nucleotide Shock.—C. J. Threlfall, H. B. Stoner and Prof. H. N. Green	297
Isolation of Octadecan-1 : 18-diol from Spanish Broom.—Dr. O. C. Musgrave, James Stark and Prof. F. S. Spring	298
Ultra-violet Absorption of Reduced Phosphomolybdate.—Dr. R. Consden and Winifred M. Stanier	298
Application of the Dische Diphenylamine Reaction to Pyrimidine Deoxynucleosides.—Dr. T. G. Brady and E. McEvoy-Bowe	299
Dutch-type White-spotting in Rabbits.—Roy Robinson	300
Mygalomorph Spider in Samoa.—Prof. B. J. Marples	300
Marsilea spp.: Materials for the Experimental Study of Morphogenesis.—A. Allsopp	301
Invalidation of the Genus *Vaughaniella*.—A. B. Cribb	302
An Insect Pest of Coconuts and its Relationship to Certain Ant Species.—M. J. Way	302

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BIOLOGY IN EDUCATION

THE recent issue of *The Advancement of Science*[1] contains the interim report of a special committee which, brief though it is, reveals a disturbing situation demanding the attention of all who are concerned in one way or another with the biological sciences. The committee was set up by the British Association to consider the position of biology and rural science in the school curriculum and matters relating thereto. The material contained in its interim report is the result of questionnaires sent to university departments of education and teachers' training colleges.

Among other findings the committee reports that in secondary modern schools biological work varies from total neglect to a few very good courses based on gardening, etc.; and that in these schools there is a grave shortage of keen, well-qualified teachers. Laboratory work is neglected. In the secondary grammar schools it finds again a serious shortage of well-qualified teachers, though the number with general degrees, or no degree, who teach the subject is increasing. If general science is offered, it is almost always in the hands of non-biologists, and biology is omitted. Out of forty-nine teachers' training colleges from which replies have so far been received, nineteen offer no courses in biology; and including all colleges together, only about 10 per cent of the entrants take biology. Both the quality and quantity of biology entrants are falling off. There is also evidence that students avoid biology since too academic a school training has prevented development of interest in the subject.

The committee does not consider that, in general, any serious hindrance is being presented to the teaching of biology through the lack of suitable laboratory accommodation. On the other hand, it finds that there is gross neglect of work with living organisms and almost total neglect of field-work. In the grammar schools, particularly, courses in biology are too academic and bookish.

To remedy this state of affairs it is felt by the committee that the vicious circle of the too academic approach must be broken in the universities, and that this can be done by much greater stress on field-work. The greater emphasis on the teaching of practical ecology, now apparent in the universities, is therefore, it considers, to be welcomed.

These findings, tentative and incomplete as they are, are in agreement with the experience of others who are familiar with biology teaching in the schools; and had the committee extended its inquiries to private preparatory and public schools it would have been able to confirm that while at sixth-form level some excellent courses in biology are now being offered, often accompanied by good work in the laboratory, and occasionally by well-planned field studies, not much biology is being taught to the younger pupils, and it is still a common experience for a large proportion of the more promising pupils to go up on the classical or literary side.

These facts lead us to the realization that in Great Britain at the present day, in comparison with such

subjects as history and literature, and even chemistry and physics, biology is playing a minor part in education. Whether at primary or secondary level, and whether in State or private institutions, as well as in the teachers' training colleges, many children and students take no regular courses in the subject at all. To others it is looked upon as a 'soft option', or as necessary preliminary training for some career. As a whole, such courses in the science of life as are offered are not felt by parents, students and teachers of other subjects to be of such significance as to induce any but a small minority of the more gifted pupils to take it up. To complete the picture, it needs to be stated that during recent months more than one biologist of considerable experience has publicly admitted that he can see no special educational value in biology.

Besides constituting a question of extreme educational importance, this state of affairs is an anthropological situation of absorbing interest.

The committee set up by the British Association is a fact-finding body; only indirectly, in emphasizing the need for more field-work and ecological studies, were its members concerned with motives. They assume that a direct association of interest exists between school and university teaching in biology. In doing this the committee is adopting a relatively narrow concept of biology as an educational medium; one, however, which is widely held by most members of the public as well as by a large proportion of biologists, and which is fostered by the departmental basis on which studies in the life sciences are pursued at the universities.

At school-level, biological studies spring from two main sources. One of these is nature study, a subject suitable for pupils of any age but which appeals only to a certain number of boys and girls, sometimes for psychological reasons. Because of this it is best looked upon as a personal hobby to be pursued chiefly as a voluntary activity. On the other hand, nature study of a more serious kind provides valuable basic training for the specialized courses which follow later at school, and which may be continued at the university.

The other source is to be found in health education. In times past much interest and effort have been put into the teaching of hygiene; but, perhaps because in this case no close link exists between school and university, the subject has failed to keep pace with the advance of medical science; its educational mission has tended to lose impetus and its popularity has waned. Hygiene, as such, is not now often found as a regular subject in the grammar schools, although, as the committee notes, it is retaining a place in the secondary modern schools, sometimes with biology as an adjunct. In making this observation the committee seems to imply that there is a distinction at school-level between biology and hygiene; that is, between biology and biological science.

In the minds of a small but growing number of teachers, such a distinction ought not to be made; the two subjects should be fused together, particularly since in any one school they are usually taught by the same member of the staff. To them it seems that while simple, utilitarian reasons for the inclusion of hygiene in the curriculum for all children are irrefutable, biology, even in the narrowest sense, should also be taught as an essential element in the comprehension of man's place in the universe. They find support for their views coming from individuals and groups of people concerned with social welfare who have been putting forward with increasing insistence demands that the schools should do more than at present in helping to solve problems of moral behaviour, juvenile delinquency, relations between the sexes, marriage breakdown, or those presented by other related social questions.

To requests of this nature, teachers have made varying responses, and a new conception of the educational mission of biology has begun to take shape, which has come to be called social biology. In this respect, it is significant to note that teachers of geography, history, and at a higher level, of economics, are also beginning to feel that greater emphasis should be placed on the social aspects of their work.

The conception of social biology is the product of no single mind or organization. It has, however, been developed farthest by the British Social Biology Council, and brought most consistently before the public through the Council's journal, *Biology and Human Affairs*. Social biology differs from biology as usually accepted in bringing man into the centre of the sphere of interest, and seeking to advance not merely his material welfare but also the whole of his culture through application of the biological sciences wherever opportunity occurs. Apart from the desire to endow biological studies with some social purpose, subject to modification in the light of further research, at no stage has any attempt been made, in Great Britain, to inject into social biology some particular bias or philosophy; its foundations remain strictly scientific. It is merely that a conscious basis has been chosen for these studies in place of the unconscious social situation which served in the past.

Social biology is also in line with what on wider considerations should be the object of all forms of science in education. Clearly, all science should be presented as one single unity, an outlook and a body of knowledge arrived at through the application of scientific method. The links between physics, chemistry and biology need to be strengthened; at the same time, all biological studies should be included, whether they relate particularly to botany, zoology, agriculture, medicine, genetics or physiology. In addition, contacts should be established with psychology and anthropology so as to embrace the other major life sciences, too.

It may be thought to be a stupendous and impossible task for any teacher to undertake to present a balanced conception of all the life sciences; yet with longer traditions behind them similar tasks are willingly shouldered by teachers of history, literature and physics. The task would be impossible at university-level; but it becomes much easier and simpler when it is realized that the school teacher is dealing with ordinary children and that a primary educational requirement is not to leave them with

mental indigestion but with minds alert to the continuing progress of science and ready to develop further understanding as they become adult. Viewed in this light, the teaching of social biology becomes a definite obligation which ought not to be shirked. It is one which is being gradually accepted by a growing number of teachers, who, however, find their difficulties increased by their relative isolation and by the varied nature of the departments, institutions and publications from which they have to draw their material.

The movement towards social biology in the schools calls for a similar movement in the universities, where at the present time departmental specialization may foster sectional efficiency but at grave risk of failure to visualize the greater whole. Yet just as the educational process extends from the cradle to the grave, lines of interest should run all the way down from the research worker to those stock figures, the man in the street and the woman in the home. Only with this wider vision does it become clear that in human progress science is fundamental, and that there can be no genuine progress without the understanding that studies of living matter alone can provide; for many of the problems that beset the world to-day, whether personal, social, communal or international, social, moral or spiritual, are essentially biological. It is a vision of this nature that is required to fire the imagination of a larger proportion of the more gifted minds among us; for these minds, particularly, need to have the ideals of truth, goodness and beauty presented to them in forms which are directly applicable in human life and associated with the main interests and strivings of humanity. Such a vision would accord to biology in the schools the status it now so sadly lacks, while at the same time solving the related problems of the poor supply, and frequently meagre attainments, of those who study and teach the subject.

[1] *Adv. Sci.*, **8**, No. 29, 66 (1951).

THE BEGINNING OF THE UNIVERSE

The Primeval Atom

An Essay on Cosmogony. By Canon Georges Lemaître. Translated by Betty H. and Serge A. Korff. Pp. ix+186. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1950.) 22*s.* 6*d.* net.

L'Univers

Par Canon Georges Lemaître. Pp. 73. (Louvain: E. Nauwelaerts, 1950.) n.p.

CANON LEMAÎTRE is well known among relativists as one who has made fundamental contributions to the theory of the expanding universe. Soon after his first work on the expanding universe, he advanced the hypothesis that the matter in the universe originally formed a giant atom, from which the atoms at present existing were produced by progressive fission. In "The Primeval Atom", the reasons which led him to this hypothesis are set out in detail. The book, which is the translation of one which appeared in French in 1946, is based on lectures and articles dated between 1929 and 1945, and intended for non-specialists.

The first lecture (1929) introduces the finite but unbounded space of relativity, and suggests that space is expanding. The second (1931) discusses the expansion of the universe in detail and then, extrapolating backward, infers that the universe began in a dense 'atom'. The third lecture (1934) considers the formation of stars and galaxies at the birth of the universe, and suggests that most stars have evolved very little since their formation. The fourth (1945) relates the concept of the primeval atom to the cosmogonic hypotheses of Buffon, Kant and Laplace. The fifth and last (also 1945) runs over the whole range of ideas covered before. In addition to these sections, there is a short mathematical appendix, a preface by Prof. F. Gonseth considering the philosophical aspects, and a foreword by Prof. H. N. Russell, specially written for the English edition.

The earlier sections are as originally written, and have not been modified in accordance with later developments. This has both advantages and disadvantages. The advantages are in giving a more vivid picture of the progress made; the disadvantages, in a certain amount of repetition. As Lemaître says, all the ideas are actually present in the last section, though this would be found too concise by most readers not prepared by reading the earlier sections.

The book certainly is a clear, vivid and fascinating account of the author's own ideas; however, it makes no reference to the divergent views of others. When the first sections were written, the author's hypothesis stood almost alone; now alternative suggestions are being vigorously examined. Lemaître infers the primeval atom by extrapolating backward from the expansion of the universe, from the progressive degradation of energy into increasing numbers of lower-energy quanta, and the progressive increase in numbers of atoms by radioactive fission. But extrapolation over such large ranges of time is notoriously unreliable. Expansion may be only an illusion; it may be characteristic of only part of the universe; or (as in the continuous creation hypothesis) it need not lead back to a dense state. Degradation of energy, though characteristic of laboratory experiments, need not apply to the universe as a whole; and present ideas suggest a progressive decrease in numbers of atoms (by the conversion of hydrogen into helium) rather than an increase by radioactive fission. Again, Lemaître quotes the existence of cosmic rays in support of his ideas; they are the relics of the display of fireworks which attended the birth of the universe. But at present it is regarded as not impossible that cosmic rays are not present everywhere in space, but are confined to the neighbourhood of the sun, or to some region of the Milky Way; and their generation by ordinary electromagnetic processes is being considered, not without prospects of success. Finally, in the light of developments of atomic theory, it is not clear what significance can be attached to the idea of an atom containing all the mass of the universe.

For all these reasons the picture presented by Lemaître must be regarded as only one of the possible pictures. Nevertheless, it is valuable to have this picture. It represents one extreme of the possible cosmogonic hypotheses—the extreme in which the beginning of the universe was as unlike the present

and the future as is possible. Such an extreme provides a comparison for assessing later hypotheses.

The translation does not seem to be wholly correct; "une trentaine" and "une trentième" seem to have been confused on p. 32, and there is more than one bad sentence on p. 49. But the difficult points are few. The translators have set out to represent as closely as possible the author's outlook, rather than to translate the words literally; and on the whole they have succeeded.

"L'Univers" is a published version of a series of broadcast talks given by Canon Lemaître in 1950. It gives a popular account of the ideas described in more detail in "The Primeval Atom".

T. G. Cowling

MEASURE AND MEASURABLE FUNCTIONS

Measure Theory

By Prof. Paul R. Halmos. (University Series in Higher Mathematics.) Pp. xi+304. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1950.) 45*s*. net.

THE theory of measure is an essential part of modern analysis, and an up-to-date treatment of it in the English language is very welcome. Prof. P. R. Halmos states that his purpose is to provide a book that should be found usable both as a text for students and as a source of reference for the more advanced mathematician. In my opinion, the advanced mathematician will find the work more useful than the student, who may be discouraged by the somewhat surprising arrangement of its contents. The preface says that "The only necessary prerequisite for an intelligent reading of the first seven chapters is what is known in the United States as undergraduate algebra and analysis. For the convenience of the reader, §0 is devoted to a detailed listing of exactly what knowledge is assumed in the various chapters. The beginner should be warned that some of the words and symbols in the latter part of §0 are defined only later, in the first seven chapters of the text, and that, accordingly, he should not be discouraged if, on first reading of §0, he finds that he does not have the prerequisites for reading the prerequisites." In fact, pp. 3–8 may well terrify the beginner, and are not needed until the last three chapters of the book are reached. If the young student omits these, he may yet be puzzled by the first sentence of chapter 1 (p. 9): "Throughout this book, whenever the word **set** is used, it will be interpreted to mean a subset of a given set, which, unless it is assigned a different symbol in a special context, will be denoted by X".

After this the book becomes more lucid, and the first seven chapters give a good account of sets and classes, measures and outer measures, extension of measures, measurable functions, integration, general set functions, and product spaces. There are many examples which are not as useful as they might have been. The author himself says (p. vi): "It might appear inconsistent that, in the text, many elementary notions are treated in great detail, while, in the exercises, some quite refined and profound matters (topological spaces, transfinite numbers, Banach spaces, etc.) are assumed to be known. The material is arranged, however, so that when a beginning student comes to an exercise which uses terms not defined in this book, he may simply omit it without loss of continuity."

Chapters 8 and 9 are rather more difficult: the former, on transformations and functions, uses the concepts of metric space, completeness, separability and uniform continuity of functions on such spaces; the latter, on probability, includes some important theorems due to Kolmogoroff. This chapter is rather outside the main stream of the argument represented by the rest of the book.

There is a great increase in difficulty in chapters 10–12, in which systematic use is made of many of the results of topology and topological group theory. These are enumerated in pp. 3–8, to which I have already referred. Chapter 10 deals with locally compact spaces, chapter 11 with Haar measure, and chapter 12 with measure and topology in groups. The book concludes with a bibliography and a list of references to it appropriate to different passages of the text, a list of frequently used symbols, and an index.

The book has many merits, and one hopes it will reach a second edition so that the author can remove the unnecessary difficulties in the first few pages, which may conceal these merits from a timid beginner.

H. T. H. Piaggio

LIFE IN THE GRAN CHACO

A Naturalist in the Gran Chaco

By Sir John Graham Kerr. Pp. xiii+235+24 plates. (Cambridge: At the University Press, 1950.) 21*s*. net.

THERE is a rich tradition of naturalist travellers in the University of Edinburgh, dating from the days of James Bruce and Mungo Park in the eighteenth century, and this record of Sir John Graham Kerr's work in the Gran Chaco of South America places him worthily in their distinguished company. It is only from this account, with its day-to-day records and connecting narrative, that one can picture, half a century and more after the events took place, the foresight and planning skill, the endurance, persistence and enthusiasm which brought to successful conclusions two expeditions to a region then practically a scientific blank.

The whole story hangs by a thread—on a bleak afternoon in February 1889 an Edinburgh medical student picks up a copy of *Nature* at the bookstall in Waverley Station, sees a note about a projected Argentine expedition to certain high tributaries of the Rio de la Plata, and so the adventure is conceived and Graham Kerr's scientific future potentially fashioned. As naturalist on Captain Juan Page's expedition, the author penetrated the Gran Chaco, and his observations, made during 1889–91, form the greater part of the book. The second part describes the Lepidosiren Expedition in the same region, undertaken with John Budgett during 1896–97.

The aims of the two journeys were different in kind: the second had a definite objective, the elucidation of the habits and early development of the American lung-fish, about which nothing was known; but that does not preclude supplementary descriptions of other notable inhabitants of the swamps. Vividly the narrative recounts the difficulties and early disappointments encountered and surmounted; and most naturalists to-day are familiar with the value of the direct results, embryological and evolutionary, which followed from the

observations and collections then made in the marshes of Paraguay.

The first journey was of another sort: it was a naturalist's roving commission, and every observation in this unobserved country came as grist to the young and enthusiastic traveller. The final and mysterious disappearance of his collections after he had left the river-steamer *Bolivia* was a serious but not a crippling loss, for the vital contributions to knowledge were the field observations recorded in this book. They include a comprehensive account of the Chaco fauna in the neighbourhood of Fortin Page; but more revealing are the innumerable notes on habits, on obliterative coloration, which in its manifold aspects clearly made a deep impression on the author, on the adaptations of the animal inhabitants of the swamps, and, most striking of all, on the characteristics of the human inhabitants, an outlying and restricted branch of the redskin Tobas, the Natokoi.

These wandering and marauding people, without huts or tents or domestic animals except the dog, unable to count above seven, recognizing the moon's phases but with no idea of the number of days in a month, depending on wooden weapons, though their bows had back-strings and their arrows were feathered to rotate, represented at its simplest a primitive hunter–fisherman stage of culture. The account of their daily routine, their simple industries and social customs makes a fascinating tale which could have been revealed only to one received into the bosom of the tribe.

The author has done well in resuscitating these old diaries, so that others may share in the observations and stimulation of his Gran Chaco adventures, which long since have borne rich scientific fruit.

JAMES RITCHIE

TAXONOMY OF *PENICILLIUM*

A Manual of the Penicillia

By Kenneth B. Raper and Charles Thom. Pp. ix+875+10 plates. (London: Baillière, Tindall and Cox, 1949.) 91*s*. 6*d*.

SPECIES of the genus *Penicillium* are of common occurrence, wide distribution, and considerable economic importance. Naturally the taxonomy of the genus has received much attention, in spite of its great difficulty. Thom himself has been studying *Penicillia* for half a century, during which time he has gradually brought order out of chaos. His monograph of 1930, though unsatisfactory in some details, laid down broad lines of classification which have stood the test of time. It is a tribute to the soundness of his work that most of the new species described by others during the intervening years are accepted by Raper and Thom in their new manual.

The book is arranged on much the same plan as the earlier "Manual of the Aspergilli" (1945), with three main sections: general discussion, the manual proper, and reference material. Although it is expressly stated that the manual is not a monograph, the first two chapters include a fairly comprehensive account of the history of the genus and synonymy. Chapter 3, "Observation and Description of Penicillia", deals fully with the morphological characters on which classification is based. Then follows a chapter on methods of cultivation and preservation of cultures, and the section concludes with a brief but useful account of the production of penicillin, the stress naturally being on the purely mycological aspects.

The second section of the book begins with a chapter on the use of the manual, and includes two keys to the main groups and series. The succeeding eight chapters deal respectively with the main groups within the genus, and the section concludes with a chapter on the three related genera, *Gliocladium*, *Pœcilomyces* and *Scopulariopsis*. Each chapter includes a key, or keys, to the series and individual species; full diagnoses, including descriptions of colonies on three different culture media; discussion of synonymy; and a section on occurrence and distribution, which not only gives a picture of the ubiquity of these organisms, but also provides a useful fund of information on their biochemical characteristics. There are numerous illustrations from photographs of colonies, and photomicrographs and drawings of typical fruiting organs, also ten plates in colour.

The final section of the book comprises a topical bibliography, covering most of the literature on systematics and activities of *Penicillia*; a general bibliography; check list of species and genera, accounting for all names which have been applied to *Penicillia*, and other names which are synonyms of *Penicillium* and the three related genera; and finally a list of accepted species.

The "Manual" is a magnificent piece of work, deserving of the highest praise. Everything has been done to aid the student of the genus and to simplify identifications. Thom's conception of 'group species'—fundamentally the recognition that, in any species of living organism, no two individuals are identical—has been extended to cover the majority of the 137 species recognized. In addition, closely related species are grouped into 'series', the results of this classification being embodied in a diagrammatic key (p. 120) which makes the approximate identification of any isolate a comparatively simple matter. Another excellent feature is the direct comparison of the various species belonging to a single series. Anyone familiar with Thom's monograph will notice that a number of species have now been transferred to different series or groups. In all such cases the new classification makes for a more rational grouping, and will facilitate identifications.

A few minor points require criticism. The term 'phialides' is not of Latin origin, and the singular is not 'phialis' (p. 45). The antibacterial spectrum test, as an aid to confirming identifications of some species, is useful, but no mention is made of testing culture fluids with ferric chloride, a test which is simpler to carry out and which has a wider application. Few mycologists would agree with the statement that the chlamydospores (or aleuriospores) produced by *Pœcilomyces varioti* have any connexion with ascus formation in *Byssochlamys fulva*. The topical bibliography, a most useful adjunct to the taxonomic sections, is unfortunately marred by many orthographic errors, chiefly in the German titles of papers. These, however, are small blemishes in a first-class book, which is likely to remain the standard treatise on *Penicillium* for many years to come.

The format of the book maintains the high standard set by the earlier "Manual of the Aspergilli", and the text is commendably free from misprints. In spite of its somewhat high price the book should, and undoubtedly will, become an indispensable part of the equipment of every serious student of moulds.

G. SMITH

Medical Botany

A Hand-book for Medical Men and All who are Concerned in the Use of Plants; Nutritionists, Dieticians, Pharmacists and Veterinarians. By Dr. Alexander Nelson. Pp. xi+544+16 plates. (Edinburgh: E. and S. Livingstone, Ltd., 1951.) 30*s*. net.

THIS book sets out to give an account of the uses to which plants can be put by man as food and drugs and also of those plants which directly cause disease or injury to man.

The field covered is very wide and thus the amount of information which can be conveyed under any one heading is rather small. This results in the book being too generalized for the serious student of dietetics or nutrition or pharmacology and not elementary enough for the "members of the general public" mentioned in the introduction.

The most serious criticism of this book which can be offered is that the information contained is thrown together without any attempt at a critical assessment on the part of the author. This, together with a somewhat unkind use of the English language, makes recommendation impossible.

Two quotations must suffice to illustrate these points. On p. 209, in the section on the broad bean, occurs the following sentence: "Apart from the use of garden beans in the young state, these seeds are used, almost exclusively, for stock food. A bean feast was not a feast of beans—the name has quite a different origin." (But we are not told what this different origin is, which is a pity; though authorities do not seem clear about it. The term may have originated from the custom of having a feast on Twelfth Night when a cake with a bean buried in it was cut; the person who received the slice containing the bean was elected 'bean-king'.)

Again, from p. 464 comes the following: "The probability of addiction following the use of opium and its derivatives has led to an increasing degree of control being exercised by governments on the growth of the poppy and the subsequent handling of the drug." Which sentence, taken at its face value, means that government controls must be added to the factors limiting plant growth.

Finally, not all will applaud the classification of alcohol as a food while tea is considered as a drug.

G. E. H. Foxon

Giordano Bruno

His Life and Thought. With annotated translation of his work, On the Infinite Universe and Worlds. By Dorothea Waley Singer. Pp. xi+389+9 plates. (New York: Henry Schuman; London: Constable and Co., Ltd., 1950.) 40*s*. net.

GIORDANO BRUNO the Nolan (1548?–1600) presents us with a problem of exceptional interest both for philosophers and historians of science. Scarcely less important is the place which he occupies in the development of ecclesiastical politics. As a personality, too, he is without rival among extreme psychological types, conditioned by a series of complex events. It is impossible to read this book without an intense sympathy for this "martyr of science", notwithstanding his infuriating follies.

Bruno's philosophy is essentially that of "an infinite universe with an infinity of worlds". Several consequences follow, of which his formulation at least cannot be regarded as particularly original. His role was more that of a seer. But, oddly enough, his cosmology stemmed from two opposing roots, namely, those of Lucretius and of Cusanus. The former's thought was fundamentally mundane, the latter's subservient to his theology.

As the theme unfolds, we see something of Bruno's couple of years in Elizabethan London, of his rare periods of comparative repose, and of the gathering storm, culminating at the stake. Of special value is the annotated translation of his "On the Infinite Universe and Worlds". Like his great contemporaries, the humanist architects, Bruno found fascination in numbers, and in a certain species of transcendence.

Mrs. Singer has performed a great task—her erudition and restraint make the living and dying of her fulminating hero a stern reality in this twentieth century.

F. I. G. Rawlins

Synthetische Methoden der organischen Chemie

Von W. Theilheimer. Repertorium 3. Pp. viii+412. (Basel and New York: S. Karger, 1949.) 40 Swiss francs.

THIS volume is the third of a series devoted to an attempt at the systematic recording of new synthetic methods in organic chemistry. Such a classification involves inherent difficulties which the author overcomes by the introduction of a novel system of reaction symbols representing processes such as addition, elimination, rearrangement and exchange, which are used in conjunction with a few empirical rules. For the casual reader who may have neither the time, nor perhaps the inclination, to master this new technique, there is an alphabetical subject index which covers the first three volumes.

It is not clear on what basis the selection of material is based. It is sometimes difficult to decide with certainty whether a reaction is in fact new, and even more difficult to decide whether a given method is an improvement on a known process or not. In these circumstances, the selection of the subject-matter must become largely a matter of personal experience and opinion. The present volume refers mainly to publications of 1946 and 1947 and contains a high percentage of references to work published in the United States, which is intended to compensate in some measure for the paucity of American references in Vol. 2.

The volumes in this series are likely to be of some value to research workers and others engaged in preparative organic chemistry, in that they provide that type of information which might otherwise be difficult to locate. The inclusion of the "English Index Key" grossly underrates the intelligence of the average English-speaking reader.

Advanced Organic Chemistry

By Prof. Reynold C. Fuson. Pp. x+669. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1950.) 64*s*. net.

THIS book departs from the usual structural method of depicting organic chemistry, with its use of homologous series and well-defined compound groupings (for example, amino-acids, steroids, etc.) as didactic stepping-stones. Instead, it concentrates on the reactions of the fundamental organic radical groupings in an attempt to delineate "the fundamental behavior patterns of organic compounds"; the emphasis throughout is on the practical, and theoretical concepts are kept to the bare essentials. This method of presentation combined with the

succinct, factual style used throughout has produced a book reminiscent of the well-known Houben–Weyl "Die Methoden der Organischen Chemie", of which this publication may indeed be regarded as a modern corollary. It is thus a reference work rather than a text-book and as such it performs its function admirably. It is a mine of well-arranged and well-chosen information documented by leading references characterized by their up-to-dateness; the text is remarkably free from errors, the printing clear and the binding admirable.

It should be emphasized, however, that this book is not suitable for the beginner in organic chemistry who is not completely familiar with the fundamental framework of the subject as usually taught. In my opinion the optimum usefulness of the book would accrue to graduates or near-graduates who are being initiated into research. R. A. RAPHAEL

Industrial and Safety Problems of Nuclear Technology

Edited by Prof. Morris H. Shamos and Prof. Sidney G. Roth. Pp. xiii+368. (New York: Harper and Brothers; London: Hamish Hamilton, Ltd., 1950.) 4 dollars: 28*s*.

THIS book collects the contributions made at a three-day conference sponsored by the United States Atomic Energy Commission and Division of General Education of New York University. The subjects cover a very wide field, including a general talk by the chairman of the Atomic Energy Commission, together with an account of its contractual and patent arrangements. There are a section on radiochemistry and isotopes, one on the design and equipment of radiochemical laboratories, and finally six articles on radiation hazards, their evaluation and control.

Many of these articles are too short and scrappy to have justified publication. For example, a single article of five and a half pages on electronuclear apparatus describes particle accelerators and their protective shielding. The articles on general hazards of nuclear radiation and evaluation of radiation hazards and their control give no table of agreed tolerances.

The only articles of any substantial value are one by P. C. Aebersold on the present and potential uses of isotopes, and another by C. Rosenblum on what isotopes can mean to industry. Industry in Great Britain has been slow to realize the potentialities of isotopes as a research tool. These articles give some very interesting examples of work which has been carried out in the United States, particularly on the mechanism of synthesis of hydrocarbons and on the role of polymerization catalysts.

J. D. COCKCROFT

Mothproofing

By R. W. Moncrieff. Pp. 200+10 plates. (London: Leonard Hill, Ltd., 1950.) 17*s*.

THE damage caused to wool and related fibres by certain kinds of moths and beetles has been known since the dawn of history, but it is only within comparatively recent years that a systematic study has been made of the habits of these pests and of methods for combating them. The economic importance of moth-proofing is reflected in the very large number of substances recommended for the purpose, and the appearance of a book on this subject at a time of world shortage of wool is particularly appropriate.

The first three chapters deal with the life-history of the various insects, their habits and the damage they do and, logically, should have been followed by Chapter 12 on the nutritional requirements of the larvæ. The chemistry and methods of application of the more important classes of moth-proofing substances are then described in some detail, many extracts and examples being quoted from the relevant patent specifications; the cost and fastness to washing of the various processes are also discussed. Another line of approach to the problem is one based on modification of the structure of the wool molecule, and an interesting account is given of Harris's pioneer work and of the author's glyoxal process. For the care of materials which have not been moth-proofed, special infestation precautions and remedies are called for, and the directions given in Chapter 15 will be of general interest. The concluding chapters give details of standardized procedures for breeding and rearing moths and for the larval and chemical testing of moth-proof efficiency.

The book is written in a lively and stimulating fashion and will appeal not so much to the specialist as to the general reader who wants to get a detailed picture of the progress made in this field of research. The illustrations and index are good, and there are ample references to scientific and patent literature.

British Birds

By F. W. Frohawk. Pp. 256+31 plates. (London and Melbourne: Ward, Lock and Co., Ltd., 1951.) 17*s*. 6*d*. net.

THE late F. W. Frohawk was well known not only as a sound and careful naturalist but also as no mean bird and insect artist. His accurate and beautiful sketches of British butterflies told us that. Now we have in this volume 105 colour illustrations of birds on the British list, accompanied by excellent letterpress, in which the information is given under the headings of "Distribution", "Description", and so on. It is easy to look up any species and any detail concerning it. This will be a very useful volume to the novice needing help in identification and information about habits. He will find in it all the birds normally met with in our countryside and many not ordinarily found there.

If the author and artist had lived a little longer, we may surmise the book would have been yet more comprehensive and that he would have included such species as the Scottish crested tit, which is somewhat surprisingly omitted. There are a large number of useful black-and-white sketches included in the text; there is also a helpful appendix dealing with recognition, a number of tables being given in which species are arranged alphabetically under "Haunts", "Size and Colour (General Impression)", "Head", Wings", "Flight", etc.

Reverting to the colour plates, colour reproduction is notoriously tricky, and it may be doubted if every reproduction does justice to the originals, for in some cases the tints are a little hard; however, the volume as a whole is excellent and it will form an admirable present for the young person with bird-watching aspirations, who should read the paragraph on "Record Keeping" and mark the last sentence concerning the value of accurate notes . . . "This type of record-keeping forms the only alternative to the destruction of many of our finest and rarest birds whose skins are kept for 'identification purposes' ".

FRANCES PITT

ACOUSTICS OF THE ROYAL FESTIVAL HALL, LONDON

By P. H. PARKIN

Building Research Station (Department of Scientific and Industrial Research), Watford

At a recent meeting of the Acoustics Group of the Physical Society, the late Dr. Alex. Wood remarked that when he was a young man at the beginning of the century the problems of concert hall acoustics had been solved. Sabine[1] had recently defined and measured reverberation time; all that was necessary was to adjust the reverberation time of a concert hall to a certain optimum value and then to sit back and enjoy the music. Nowadays, Dr. Wood continued, we know that we are only beginning to discern the problems of designing a concert hall with excellent acoustics.

The theory of sound waves in rooms has received considerable attention, from Lord Rayleigh[2] to the recent publications by Morse and Bolt[3], and others. The theoretical solutions of quite simple practical acoustical problems are, however, so complicated that their application is very limited, even if all the physical factors were known. For example, it has been pointed out that the solution of the steady-state sound in a rectangular room, one wall of which has on it a few patches of absorbent flush with the surface, requires a notation of more than sixty-five symbols. When we remember that musical sounds are mostly transient in character, it is clear that for some time to come the approach must be an experimental one. With so incomplete a background it may be asked[4] why science should be consulted at all in the design of a concert hall. The answer is that the man of science forms a link between the architect and the musician: however imperfect the scientific knowledge, it is a better basis than any other for the intelligent guesses which have to be made.

One major contribution of science to the design of the Royal Festival Hall on the South Bank, London, has been an attempt to assess and define the musical requirements. Hitherto the worker in acoustics has tended to rely on his own subjective judgments, an unethical practice, but one which has been largely forced on him by the lack of organized musical opinion. This assessment started in 1947 when a questionnaire was sent to all professional musicians who could be classified as listeners (as distinct from performers), in which they were asked their opinions on the acoustics of ten selected concert halls. Also, listening tests were made in several halls, where teams of listeners sat successively in different positions during concerts. From such tests as these; from public meetings such as the one organized by the Acoustics Group of the Physical Society[5,6] where musicians, architects, engineers and physicists met to discuss the problems; and from private discussions with musicians and other workers on the subject, it was possible to formulate the musical requirements. The positive virtues required are: (1) definition, (2) fullness of tone, (3) blending, and (4) balance; the negative virtues required are (5) a low level of intruding noise and (6) no echoes.

There is a further requirement which did not arise from these discussions, and that is for the acoustics to be reasonably uniform over the whole audience area. Professional musicians usually sit in the acoustically best seats, and are not always aware of the need for uniformity.

Turning now to the design problems, and taking the negative requirements first, the sound insulation was the second contribution of science to the design of the Royal Festival Hall. It was, of course, necessary to know the noise-levels on the site and the permissible noise-levels inside a concert hall. The outside levels, which were caused by the trains over Hungerford Bridge, were easily measured; the permissible inside levels were more difficult to determine. To reduce the external noise to inaudibility in the Hall would have required an excessively complicated structure. Instead, measurements of the sound-pressure levels due to nearby main-road traffic were made, during pauses in quiet passages of music, in two concert halls. Teams of listeners in these halls during concerts were not conscious of the intruding noise. As a design principle, it was decided to insulate the auditorium itself to this standard and not to rely on any additional insulation obtained from the surrounding foyers and corridors. The insulation of the proposed wall and roof was checked on the site by building a hut of the same construction. After the Hall had been under construction for some months, the railway authorities relaid the tracks on Hungerford Bridge, and the noise-level decreased by 18 decibels. The old rails had become badly corrugated; this phenomenon is not fully understood and the new rails may eventually become corrugated, although after two years use they have shown no sign of doing so. This reduction in the noise-level and the additional insulation due to the surrounding foyers have made the Hungerford Bridge trains completely inaudible in the auditorium. The actual insulation achieved has not yet been measured, as it is now necessary to construct microphones which will measure below the threshold of audibility.

Another possible source of noise in the Hall was the underground trains which run directly under the site. The vibrations due to these trains were measured on the foundations of the old brewery then existing on the site. The maximum vertical amplitude (peak-to-peak) was of the order of 0·0002 in. at 10 c./s., and although this amplitude of vibration is classified as 'not perceptible' to the human frame, it was very difficult to decide whether audible frequencies would be produced in the Hall, for example, by exciting wood panels. It was decided that the risk would have to be accepted without attempting structural precautions. In fact, there was the possibility in reserve of putting the underground rails on resilient mountings. In the event, one underground train out of four or five, presumably due to differences in the rolling stock, produces maximum noise-levels in the Hall of about 30 phons. This noise would not be distinguishable if it were not for the otherwise very quiet conditions. At the first test concert, 240 listeners were specially asked to listen for the trains; only eighteen thought that they could hear them, and then, of course, only when they coincided with pauses in the music.

The other negative requirement, no echoes, was met mainly by due regard to the shape of the Hall,

but also by absorbent treatments of various kinds on the rear wall, along the junctions of the side walls and the ceiling, and on the side walls close to the orchestra where lateral echoes might have occurred.

There is another fault, not listed by the musicians, which may occur in halls. This is the occurrence of one or more particular eigentones with a decay time much longer than the general reverberation time. Such a fault occurred in the large concert studio in the Danish Broadcasting House, and in that case was cured by inserting Helmholtz resonators in the ceiling, tuned to absorb 63 and 98 c./s.[7]. The ceiling of the Royal Festival Hall was constructed with about twelve hundred 2½-in. diameter holes for use with resonators if the need arose.

Dealing now with the design problems associated with obtaining the positive musical requirements, it must be emphasized that the following statements should be regarded as hypotheses. The two major requirements are for definition and fullness of tone. The meaning of definition is obvious; fullness of tone is not so obvious. Apparently musicians mean the same quality when they use such terms as warmth, richness, body, singing tone, sonority or resonance. (It should be remembered that 'resonance' has different meanings for the musician and the physicist; the "Oxford English Dictionary" defines it as the reinforcement or prolongation of sound by reflexion.) It is reasonable to assume that, other considerations apart and within limits, the longer the reverberation time the more chance there is of achieving this quality. If this is so, there must be some conflict between 'definition' and 'fullness of tone'.

Definition can be obtained by a clear path for the direct sound from all the instruments to all parts of the audience. The intensity of this direct sound will, at least for individual instruments if not for the whole orchestra, decrease as the square of the distance. In the Royal Festival Hall the intensity of the direct sound at the back of the Hall would be 20 decibels less than in the front row, while the reverberant sound, by definition, would be approximately of the same intensity throughout the Hall. Now for reasonable uniformity the ratio of direct sound to reverberant sound should not vary too greatly, and we know from Haas's work[8] that, for speech at least, the direct sound can be followed shortly after by reflexions of intensity greater than the direct sound without any loss of definition. That is to say, there is a time limit; reflexions which arrive at the listener within this limit can be classified with the direct sound and do not detract from the definition; reflexions arriving after this limit can be classified as reverberant sound and hinder definition. For speech this time is about 30 msec. and for music we can assume that it is of the same order. The canopy over the orchestra in the Royal Festival Hall is designed to reflect sound towards the rear of the Hall in order to maintain the intensity of the direct plus 'first-reflected' sound. To achieve fullness of tone, the Hall was designed to have as long a reverberation time as possible; the absorbing surfaces were kept to the minimum necessary to prevent echoes, and the volume of the Hall was made as large as was structurally possible.

The primary purpose of the four trial concerts which were held in the Royal Festival Hall before its opening was to test for faults, for example, echoes, since acoustics is a wave phenomenon and predictions based on geometrical analysis may not be borne out in practice. It was clear after the first trial that there were no major faults, and attention was concentrated on the problem of definition versus fullness of tone. Again, the professional musicians were consulted, but it soon became apparent that, for musicians conditioned by ten years of listening in over-reverberant halls, the acoustics of the Royal Festival Hall were too different for reliable and consistent judgments to be made. Thus, at one trial concert, ten out of fourteen musicians wanted more fullness of tone and accordingly some of the absorbent areas were removed, at the risk of echoes. In the event, due to the remainder of the upholstered seats being installed, the reverberation time was still the same at the next trial. Nevertheless, ten of the fourteen critics volunteered the information (they were not specifically asked) that the acoustics were now considerably improved; only two still wanted more fullness and nine wanted the Hall left as it was (and is).

When the Hall has been in use for six months, it is proposed to make a detailed survey of authoritative musical opinion on the acoustics. It seems to be generally agreed at the present time that the definition is outstandingly good, and, as a result, all the parts in the most complex modern orchestrations can be heard, presumably as the composers intended. Also, mezzo forte and pianissimo passages sound excellent, due in part no doubt to the good sound insulation; but there is some argument as to the effectiveness of the louder passages. A lot depends, of course, on the orchestral layout, which there is not space to discuss, and indeed on the standard of performance. Nor is there space to discuss the problems of balance and blend. From the performer's point of view, it is worth noting that Mr. Jascha Heifetz and Mr. Yehudi Menuhin have both remarked to the Press, one in Australia and the other in America, that the Royal Festival Hall has the best acoustics of any hall they have played in. Mr. Leopold Stokowski has also remarked to the present writer that he considers it the best hall he knows, although he would prefer a longer reverberation. In comparison with the seven concert halls which the 1947 survey of musical opinion, referred to above, showed to have good acoustical reputations, the reverberation time of the Royal Festival Hall (see Figs. 1 and 2) is the longest except for St. Andrew's Hall, Glasgow, which only achieves its exceptionally long time at the expense of troublesome echoes at the front part of the hall. Fig. 1 also shows the optimum reverberation time as a function of volume as recommended by Bagenal and Wood[9] and Knudsen and Harris[10]. The measured

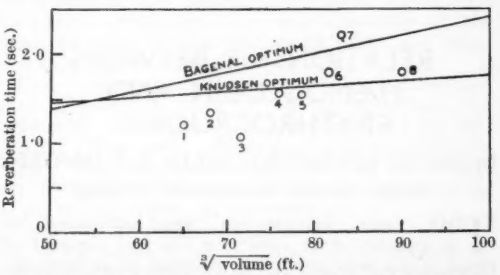

Fig. 1. Reverberation times at 500 c./s. with halls full. 1, White Rock Pavilion, Hastings; 2, Peoples' Palace, London; 3, Royal Opera House, Covent Garden, London; 4, Simon de Montfort Hall, Leicester; 5, New Philharmonic Hall, Liverpool; 6, Usher Hall, Edinburgh; 7, St. Andrew's Hall, Glasgow; 8, Royal Festival Hall, London

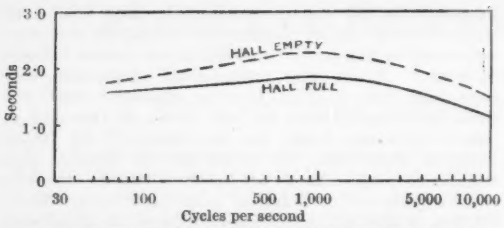

Fig. 2. Reverberation time of the Royal Festival Hall, full and empty

reverberation time takes no account of the behaviour of the sound during the first 50 or 100 msec., and it may be that because of the strong direct and first-reflected sound in the Royal Festival Hall the reverberation time could well be longer.

A final assessment must await further experience, and the problem has been elegantly put by the music critic of *The Times*, writing about one of the trial concerts[11]; after remarking that a little more 'warmth' was desirable, he continues: "Yet to be able to hear all parts within a tutti, to have the piano . . . sound in the huge hall with the intimacy of the drawing room, and really to be aware of all that is going on in a complex score like Debussy's 'La Mer' are experiences that can only be had elsewhere in the Liverpool Hall and must not be sacrificed too far to the desire of the ear for a feather bed on which to recline voluptuously".

It would not be fitting to conclude without a tribute to Mr. Hope Bagenal, the acoustic consultant, whose judgment in these problems, where so much is qualitative, has been infallible.

This work will be described in detail elsewhere; it forms part of the programme of the Building Research Board of the Department of Scientific and Industrial Research, and this article is published by permission of the Director of Building Research.

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RELATIONSHIP BETWEEN HÆMOGLOBIN AND ERYTHROCRUORIN

By Prof. D. KEILIN, F.R.S., and Dr. E. F. HARTREE
Molteno Institute, University of Cambridge

THE name 'hæmoglobin' was introduced by Hoppe-Seyler in 1864[1] for the red pigment of blood which was previously referred to as hæmatoglobulin by Berzelius (1840)[2] and hæmatocrystallin by Lehmann (1853)[3]. Stokes (1864)[4], not being aware of these terms, proposed for this pigment the name 'cruorine'. In 1868 Ray Lankester[5] announced the discovery of 'Stokes's Red Cruorine' in non-corpuscular vascular fluids of *Lumbricus*, *Eunice sanguinea* and *Hirudo*, in blood plasma of *Planorbis corneus* and in the body fluid of the larva of *Chironomus plumosus*. He noted that "in vertebrates the Red Cruorine is concentrated in corpuscles, whilst in the Mollusc, Insect and Annelid, it is diffused in the plasma". In some annelids, including *Sabella*, he found that vascular fluid contains "a green body of the same nature as the Red Cruorine of Stokes". He concluded that this "green body may be called Chloro-cruorine whilst the red is termed Erythro-cruorine. There is an indication of the existence of a violet and yellow form of cruorine in certain Molluscs. Many Annelids, very nearly all Insects, Crustacea and Molluscs have not a coloured Cruorine in their blood. Is it not probable that they possess a colourless body possessing the same oxygen-carrying properties which Stokes attributes to Red Cruorine? If so it should be classed with the red and green forms as a modification of Cruorine."

There is no doubt that Ray Lankester used the term erythro-cruorine to cover all red oxygen-carrying pigments both of vertebrates and invertebrates. However, in 1870, while retaining the term chloro-cruorine for the green pigment, Ray Lankester[6] abandoned the term 'erythro-cruorine', replacing it both in the case of vertebrate and invertebrate pigments by Hoppe-Seyler's term 'hæmoglobin', which was by this time generally accepted.

More recently, Ray Lankester's term erythro-cruorin (with slightly different spelling) was revived by Svedberg and Eriksson[7] to designate the red blood pigments of *Arenicola marina* and *Lumbricus terrestris*. The reason they gave for so doing was formulated as follows: "The detailed ultracentrifugal investigation has shown that the red respiratory pigment dissolved in the blood of these worms is with regard to the properties of the protein part of the molecule, more allied to chlorocruorin and to hemocyanin than to hemoglobin of the vertebrates. It therefore seems inappropriate to call it a modification of hemoglobin"; and further, "It seems to us appropriate to revive Ray Lankester's term and we therefore propose the name erythrocruorin for the red respiratory proteins of the invertebrates". With the limited information then available, the contrast between erythrocruorin and hæmoglobin was well defined: erythrocruorin being dissolved in plasma, having a high molecular weight (*c.* 3,000,000) and a low isoelectric point ($\sim 4{\cdot}8$); hæmoglobin being intracorpuscular, having a lower molecular weight (*c.* 68,000) and a higher isoelectric point (6·5–7·5).

The term 'erythrocruorin' was extended by Svedberg and Eriksson-Quensel[8], Svedberg and Pedersen[9], Roche[10] and Roche and Fontaine[11] to the hæmoglobin-like pigments of all invertebrates as well as of cyclostome fishes among the vertebrates, the name 'hæmoglobin' being reserved for the blood pigments of all other vertebrates.

This classification was based by them upon determinations of (1) the molecular weight, (2) the isoelectric point, and (3) the chemical composition of the proteins of these pigments. However, as will be shown presently, a thorough analysis of the results obtained under the above headings does not support the separation of these pigments into hæmoglobins and erythrocruorins.

(1) *Molecular weight.* Determinations of molecular weight of different oxygen carriers have been summarized and tabulated by Svedberg and Pedersen[9].

TABLE 1. MOLECULAR WEIGHTS OF DIFFERENT HÆMOGLOBINS (II) AND ERYTHROCRUORINS (I AND III) ACCORDING TO SVEDBERG AND PEDERSEN (ref. 9)

Lampetra	17,000	I
Chironomus	17,000	I
Glycera	34,000	I
	34,000	I
Fishes, birds and mammals	68,000	II
Amphibia and reptiles	68,000	II
	150,000	II
	290,000	II
Daphnia	400,000	III
Planorbis	1,630,000	III
Arenicola	3,000,000	III
Lumbricus	3,000,000	III

Thus, the molecular weights of erythrocruorins found dissolved in the plasma of different invertebrates vary from 17,000 to about 3,000,000 (I and III, Table 1). The values for intracellular erythrocruorin both of certain invertebrates and of cyclostomes are 17,000 and 34,000 (I, Table 1). The pigment in *Daphnia* contains a main component of molecular weight about 400,000 ($S_{20} = 16{\cdot}3 \times 10^{-13}$) and varying proportions of a smaller molecular species (about 44,000) which at *p*H 8 may constitute as much as 40 per cent of the total pigment. The hæmoglobins of mammals, birds and fishes have the mean value $S_{20} = 4{\cdot}3 \times 10^{-13}$, which corresponds to a molecular weight of 68,000, while those of amphibians and reptiles have a somewhat higher value: $S_{20} = 4{\cdot}7 \times 10^{-13}$. What is, however, of special interest is that the blood of these vertebrates, according to Svedberg and Pedersen[9], "nearly always contained a second component having S_{20} about 7×10^{-13} and probably having twice the molecular weight of normal hæmoglobin. Furthermore, in a single case a third component was observed with $S_{20} = 12{\cdot}5 \times 10^{-13}$ (molecular weight probably 4 × hæmoglobin)." In other words, the intracorpuscular hæmoglobin of certain amphibians (for example, *Bufo valliceps*) may reach values as high as 150,000 and 290,000. The molecular weights of the intracorpuscular hæmoglobins of vertebrates (68,000–290,000) occupy a comparatively small range (II, Table 1) within the very wide limits of molecular weights exhibited by erythrocruorins, which may vary between 17,000 and 3,000,000 (I and III, Table 1). Molecular weight data, therefore, give no support to the separation of these pigments into two groups.

TABLE 2. ISOELECTRIC POINTS OF DIFFERENT RESPIRATORY PIGMENTS (SEE SVEDBERG AND PEDERSEN (ref. 9), AND ROCHE AND FONTAINE (ref. 11)). I.P. OF *Gastrophilus* ACCORDING TO KEILIN AND WANG (ref. 15)

The line drawn between *Gastrophilus* and toadfish separates the so-called 'erythrocruorins' from hæmoglobins

	Isoelectric points
Arenicola	4·6
Chironomus	5·4
Lampetra	5·7
Notomastus	6·0
Gastrophilus	6·2
Toadfish	5·75–6·23
Cyprinus	6·5
Horse	6·9
Man	7·1
Duck	7·5

(2) *Isoelectric points.* The isoelectric points (I.P.) of respiratory pigments, as shown in Table 2, vary from *p*H 4·6 to *p*H 7·5. Although precise determinations have so far been carried out in only a few cases[9,11,15], yet within the above range no distinct break in the values can be observed. The line drawn between *Gastrophilus* and toadfish separating the pigments into erythrocruorins (I.P. 4·6–6·2) and hæmoglobins (I.P. 5·75–7·5) is a purely arbitrary division.

Table 3. AMINO-ACIDS IN RESPIRATORY PIGMENTS ACCORDING TO ROCHE (REF. 10) AND ROCHE AND FONTAINE (REF. 11)

Respiratory pigment of	Pigment classified as	Arginine (per cent)	Histidine (per cent)	Lysine (per cent)	Cystine* (per cent)
Lampetra	Erythrocruorin	3·52	3·37	7·51	4·40
Arenicola	"	10·04	4·03	1·85	4·08
Glycera	"	9·64	5·39	4·90	3·40
Lumbricus	"	10·07	4·68	1·73	1·47
Sabella (=*Spirographis*)	Chlorocruorin	9·64	2·38	3·64	1·64
Horse	Hæmoglobin	3·57	8·13	8·31	0·74
Horse (according to Tristram, ref. 28)	Hæmoglobin	3·65	8·71	8·51	1·01

* Cystine: the value of 1·01 given by Tristram is the sum of cysteine and cystine. Roche's figures were obtained by a method which also gives the sum of these acids.

(3) *Amino-acid content of proteins.* The estimation of a few amino-acids in pigments classified as erythrocruorins was carried out by Roche and Fontaine[11] in four cases (*Lampetra*, *Arenicola*, *Glycera* and *Lumbricus*) and a comparison was made with amino-acids in chlorocruorin of *Sabella* and in horse hæmoglobin. However, since some of this material was available only in small amounts and was of doubtful purity, the estimations can be considered as only approximate. Even if we accept the values shown in Table 3, there is no indication of uniformity in amino-acid distribution among different erythrocruorins. Whereas the arginine and lysine contents of *Lampetra* erythrocruorin are very similar to those of horse hæmoglobin, the values for histidine and cystine are not far from those found in the pigments of the invertebrates. On the other hand, if their cystine contents are compared, the pigment in *Lumbricus* is more closely allied to horse hæmoglobin than to the pigment in *Arenicola*. Thus, the amino-acid contents of these oxygen carriers do not support their separation into erythrocruorins and hæmoglobins.

Other Properties of Oxygen Carriers

The comparative study of protohæm–protein oxygen carriers of different origin reveals that they differ between themselves not only in the three properties examined above, namely, their (1) molecular weight, (2) isoelectric point, and (3) amino-acid content, but also in other important properties, such as: (4) solubility, (5) ease of crystallization, (6) crystalline structure, (7) affinity for oxygen, (8) relative affinity for oxygen and carbon monoxide, (9) shape of the oxygen dissociation curve, (10) absorption spectrum, (11) autoxidizability of the iron, (12) ease of denaturation by alkali and other factors, and (13) antigenic properties.

Unfortunately, only three of these properties have been investigated more or less systematically for respiratory carriers both of vertebrates and invertebrates. These are: affinities of the pigments for oxygen, their relative affinities for oxygen and carbon monoxide and the positions of their absorption bands in the visible region of the spectrum.

Affinity of the respiratory pigments for oxygen. This can be expressed in terms of the oxygen tensions in millimetres of mercury (p_{50}) at which the pigments are half-oxygenated. This property has been extensively investigated because of its great physiological significance. The scattered literature on this subject up to 1933 was collected and critically reviewed by

Table 4. Affinities of Respiratory Pigments for Oxygen
Oxygen tensions (p_{50}) in mm. mercury, for 50 per cent oxygeration of pigments in the blood of different organisms; (*a*) as determined by Fox (ref. 13), (*b*) as quoted by Redfield (ref. 12). The pigments of organisms named in italics are classified by Svedberg and Roche as erythrocruorins

		p_{50}		
		17° C.; no carbon dioxide	17° C.; + 1 per cent carbon dioxide	38° C.; + 5 per cent carbon dioxide
(*a*)	*Chironomus riparius*	0·6	0·6	
	Tubifex sp.	0·6	—	
	Ceriodaphnia laticaudata	0·8	1·0	
	Thalassema neptuni	1·4	1·8	
	Arenicola marina	1·8	2·6	
	Planorbis corneus	1·9	2·9	
	Daphnia magna	3·1	4·9	
	Man	1·2	3·9	
(*b*)	Man			26
	Horse			26
	Sea lion			40
	Eel	2–3		
	Pike	2–3		

Redfield[12], while more recently Fox[13] has determined p_{50} for a number of invertebrate pigments by micro-spectroscopic methods. A few examples selected from these papers as having a direct bearing on the relationship between oxygen carriers of vertebrates and invertebrates are given in Table 4. In all cases the determinations were carried out on whole blood. To these examples we can add the values of p_{50} = 0·1 mm. at 15° obtained by Keilin and Wang[14] for the hæmoglobin of the root nodules of leguminous plants and p_{50} = 5 mm. at 39° obtained by Keilin and Wang[15] for the hæmoglobin of tracheal cells of *Gastrophilus* larvæ. An exceptionally high affinity for oxygen is shown by the hæmoglobins of *Ascaris lumbricoides*. This organism, as was found by Keilin[16], has two distinct hæmoglobins, one in the perienteric fluid, the other in the body wall. It was recently shown by Davenport[17] that both these hæmoglobins exhibit a remarkable resistance to deoxygenation. Thus, in the presence of sodium hyposulphite the half-time (t_{50}) for deoxygenation is 150 sec. for perienteric and 80 sec. for body-wall hæmoglobins, as compared with 0·008 sec. for sheep hæmoglobin.

All the available data clearly indicate that p_{50} values, like the oxygen dissociation curves, do not follow at all the classification of pigments into hæmoglobins and erythrocruorins. On the contrary, they only reflect more or less consistently the physiological requirements of the organisms, such as can also be illustrated by the relationship between blood hæmoglobin and myoglobin of the same organism, or between maternal and fœtal hæmoglobins. Moreover, since p_{50} decreases when a solution of hæmoglobin is diluted[18], a comparison of the pigments in Table 4 at equal hæmoglobin concentrations would, if anything, further diminish the distinction between hæmoglobins and erythrocruorins.

Relative affinity of the respiratory pigments for oxygen and carbon monoxide. This ratio is expressed as an equilibrium or partition constant

$$K = \frac{[\mathrm{HbCO}]p\mathrm{O_2}}{[\mathrm{HbO_2}]p\mathrm{CO}}.$$

The value of this constant for the hæmoglobins of certain vertebrates was determined by Anson, Barcroft, Mirsky and Oinuma[19]. The problem was recently carefully re-investigated by Fox[20], who determined this constant for the oxygen carriers of several vertebrates and invertebrates. The results of these determinations, together with the data obtained for the pigments in the root nodules of leguminous plants[14] and the tracheal cells of *Gastrophilus* larvæ[15] as well as for myoglobins of different mammals, are summarized in Table 5.

Table 5. Values of $K = \frac{[\mathrm{HbCO}]p\mathrm{O_2}}{[\mathrm{HbO_2}]p\mathrm{CO}}$ for different respiratory pigments according to Fox (ref. 20), except for root nodules and *Gastrophilus* (Keilin and Wang, ref. 14, 15). Pigment of *Branchioma* is chloro-cruorin; those marked with an asterisk belong to the supposed erythrocruorins, the remainder to the hæmoglobins

	K
Branchioma	570
*Chironomus**	400
Horse	280
Man	230
*Arenicola**	150
*Tubifex**	40
*Planorbis**	40
Rabbit	40
Root nodules*	37
*Gastrophilus**	0·67
Myoglobins	28–51

As in the case of oxygen affinities, no line can be drawn separating the values of *K* for erythrocruorins and hæmoglobins.

Absorption spectra. That the absorption spectra of hæmoglobins of different origins are not the same was shown for the first time by Sorby[21] in 1876 in his classical paper "On the Evolution of Hæmoglobin". In comparing human and *Planorbis* hæmoglobin, he found that the absorption bands of the latter lie about 3 mμ nearer the blue end of the spectrum. Sorby did not fail to give the correct interpretation of this phenomenon, as the following quotation shows: "This difference cannot be due to any difference in the physical state of the substance since in both cases it was perfectly dissolved in a relatively large quantity of water. It is rather of such a character as would result from the substitution of one kind of albuminoid for another in the combination with the same modification of hæmatin, into which both are decomposed when boiled with ammonia or decomposed by acids." Sorby also found that these pigments differ in their susceptibility to heat and to acids. These observations were confirmed by Vlès[22] and by Anson *et al.*[19], who extended them to hæmoglobins of a greater variety of organisms. However, since most of these data were obtained with impure material and not with modern and more precise spectrophotometric methods, they can only be considered as approximate and need not be recorded here. Nevertheless, they clearly show that the positions of the absorption bands of different hæmoglobins are irregularly distributed between those of pigments classified as erythrocruorins.

General Considerations

Although the oxygen carriers of different organisms show marked differences in their properties, not one of these properties supports the classification of the hæm–protein compounds into erythrocruorins and hæmoglobins. In fact, it is primarily the important advance made in the study of this subject by Svedberg himself that has made it impossible to retain the term 'erythrocruorin' which he introduced during the first stage of his work on the oxygen carriers of invertebrates. The term 'erythrocruorin' can therefore be abandoned and all protohæm–protein oxygen carriers should now be brought together under the general term 'hæmoglobin'. The specific cases of these pigments can be referred to as hæmoglobins with an appropriate indication of their origin; for example, human hæmoglobin, *Planorbis* hæmoglobin,

Gastrophilus hæmoglobin, etc. Muscle hæmoglobin can be referred to as myohæmoglobin, which is usually abbreviated to myoglobin.

The hæmoglobin of the root nodules of leguminous plants is of special interest. It was discovered by Kubo[23] and its oxygenation was demonstrated by Keilin and Wang[14], who also determined the spectrophotometric curves of its main derivatives and its affinities both for oxygen and carbon monoxide. What is remarkable, however, is that neither the plant cells alone nor the symbiotic micro-organism (*Rhizobium*) cultivated separately are capable of synthesizing hæmoglobin. It is only when the root cells are invaded by the specific micro-organism and begin to proliferate that hæmoglobin is formed. *Rhizobium* not only induces growth and multiplication of the cells but also supplies these proliferating cells directly or indirectly with a factor necessary for synthesis of hæmoglobin[14]. Root nodule, or simply nodule, hæmoglobin is an appropriate name for this pigment, since it gives sufficient indication of its peculiar localization and dependence upon an association between the plant cells and *Rhizobium*. (The name 'leghæmoglobin' proposed for this pigment by Virtanen[24] is not suitable since the prefix 'leg' is not an adequate abbreviation of the Latin *legumen* and is ambiguous in English.)

We shall now briefly consider the term 'chlorocruorin' which was introduced by Ray Lankester in 1868 for the green blood pigment of certain polychæte worms. Chlorocruorin was re-investigated by Fox[20,25,26], who, in a series of important papers on this pigment, established its characteristic properties. Chlorocruorin differs from hæmoglobin in the structure of its hæm as well as that of its protein. The hæm, according to Fischer and Seemann[27], differs from protohæm in having one of its vinyl side-chains replaced by a formyl group. The term 'chlorocruorin' should be retained, since it indicates the green colour of the pigment; it also suggests a marked difference from hæmoglobin and is closely associated with the extensive investigations on this subject by Fox and other workers.

It may be interesting to mention here that the blood of polychæte worms generally contains either hæmoglobin or chlorocruorin or is devoid of both pigments. However, it was recently found by Fox[20] that the genus *Serpula* differs from all other known organisms in possessing two oxygen carriers, hæmoglobin and chlorocruorin, in the blood plasma.

Since the prosthetic group of all hæmoglobins is the same protohæm nucleus, the differences in their properties, as was clearly formulated by Sorby[21], is due to differences in the nature of the protein portions of their molecules. What is of special importance is that in spite of the great variety in the amino-acid contents of these proteins and the great diversity in their physico-chemical properties, they all have one character in common, and that is the ability to impart to the hæm nucleus the remarkable property of reversible oxygenation. This important property, which cannot be imitated by any other naturally occurring or synthetic compound, depends upon the integrity of the structural configuration of the protein and is abolished when the protein undergoes denaturation. By bringing together all protohæm–protein oxygen carriers into the one group—hæmoglobin—one's attention becomes rightly focused upon their common fundamental property of reversible oxygenation, the intimate mechanism of which still awaits elucidation.

To avoid confusion and unnecessary complications of nomenclature, the classification of all biologically active protein compounds, such as oxygen carriers or enzymes, should be based not upon their physico-chemical properties as proteins but upon their specific biological activities and the nature of their active, or prosthetic, groups.

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THE COSMIC RAY OBSERVATORY AT OTTAWA

By Dr. D. C. ROSE

National Research Council of Canada

THE National Research Council of Canada has recently constructed at Ottawa a small observatory for cosmic ray measurements. Such an observatory at or near sea-level (the present site is about 200 ft. above mean sea-level) may be considered novel at a time when so much important work is being done at high altitude. There are still, however, many interesting things to be learned from sea-level measurements, and the advantages of fixed rather than airborne apparatus are great. Practically all the nuclear phenomena (probably all except collisions due to heavy energetic primary particles) occur at sea-level, though less frequently than at higher altitude. Many experiments which require continuous observation can only be carried out with fixed equipment, and few long-term measurements which depend on geomagnetic effects have been taken at the high geomagnetic latitude (56·8° N.) at which the new laboratory is situated.

The programme of work, which was started about three years ago and was moved recently to the new observatory, includes the study of the nature of cosmic ray particles and showers at sea-level, and experiments which would lead to more information about the source of cosmic rays.

The new building was designed to supply laboratory facilities wherein the amount of absorbing material

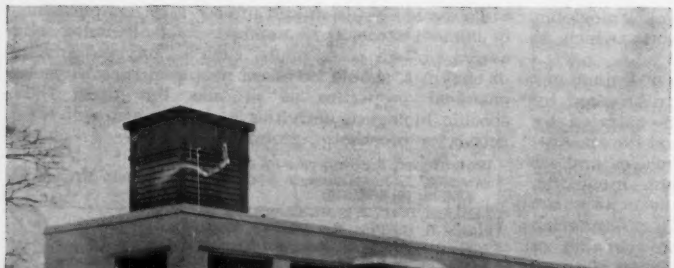


Fig. 1. The cosmic ray observatory at Ottawa (December 1950)

could be known and varied at will without interfering with building structures. Further, the increasing use of accelerators and radioactive material was putting serious limitations on the cosmic ray measurements that could be taken at the main laboratory headquarters of the National Research Council. A site was chosen well away from other buildings and located on high ground with a clear vista in all directions from the roof.

The building is essentially an observatory and has no space for the construction of apparatus. These facilities remain in the main laboratory, about four miles away. The observatory is, however, located in the same area as the aeronautical and mechanical engineering laboratories of the National Research Council, so supplies are readily available. There is also transportation every hour throughout the day each way from this area to the main laboratories.

The inside dimensions of the building are 50 ft. by 12 ft., and except for a small wash-room and dark-room at one end, the interior is not partitioned. It is one story high and has a flat roof, the roof being used for experimental purposes. An area on the roof, 6 ft. by 12 ft. at one end, is reinforced to carry heavy loads up to 10 tons. The rest of the roof is designed for 50 lb. per square foot, so that it can carry lighter equipment.

There is an opening in the roof six feet square over the centre of the laboratory space. This opening has a movable cover which in suitable weather may be left off, or at other times covered with light weather-proof material of known absorbing power. Experiments in which the exact quantity of absorber overhead must be known can, therefore, be carried out anywhere on the roof if the total weight is low, on the reinforced area if the weight is large, or in the laboratory below the opening. For work on the roof, which is carried out in all weathers, movable penthouses have been constructed. These are heated electrically and the temperature is controlled.

The floor of the laboratory is of hard wood laid on concrete. The concrete was poured on a rock fill about two feet thick lying on solid rock. The floor will, therefore, hold very heavy loads, and there is no hesitation in building a lead castle weighing several tons around measuring apparatus in any part of the laboratory.

The building and the furniture, with the exception of a desk and chairs, are of fire-proof construction, the floor and the window frames being the only wood in the structure. This fire-proof construction was followed because a considerable quantity of electronic and recording apparatus is left running continuously, and even with careful engineering it is possible that something may become overheated and start a fire. The building is left unattended for long periods, at night and over week-ends, and an attempt has been made to arrange all equipment which is operating continuously so that, should one component burn up when there is no one in attendance, it will do no more harm than put that piece of equipment out of order and make a certain amount of smoke. Fig. 1 shows a picture of the building from the front, and Fig. 2 is an inside view showing a rack of scalers and recording apparatus.

The plans for the equipment of the observatory included ionization chambers, Geiger–Müller counters with associated coincidence and anti-coincidence circuits, proportional counters and Wilson cloud chambers. Up to the present, there has been some specialization in Geiger–Müller counter work and ionization chambers. Wilson cloud chambers have not yet been used, but will be built in the near future. The facilities for the construction of apparatus in the National Research Laboratories are considerable, and all the apparatus except the Geiger–Müller

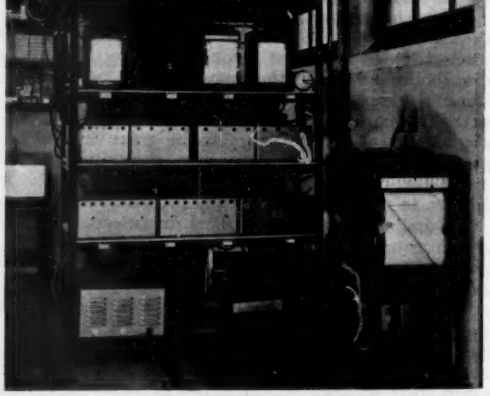


Fig. 2. Rack carrying scalers and recording equipment. The recorder at the right is a differential rate meter

tubes themselves and the recording instruments are constructed in the laboratories.

One of the important experiments is to keep a continuous watch for sudden increases in the cosmic ray intensity associated with solar flares, such as that observed on November 19, 1949 [1]. Counter telescopes are used for these measurements. Another major investigation being undertaken with counter telescopes is a thorough study of north–south and east–west asymmetry in cosmic ray intensities. At high geomagnetic latitudes and particularly at large zenith angles, the north–south asymmetry is as prominent as the east–west differences, and both may be sensitive to geomagnetic disturbances.

Counters are also being used in a study just completed of the directional intensity of mesons and in another on the angular spread of penetrating showers. This latter experiment is being followed up by a study of the production of local penetrating showers in different materials. For this study, large quantities of absorbing materials of different atomic weight, namely, lead, copper, aluminium and carbon, have been obtained.

An attempt has been made to standardize some of the electronic equipment used in the observatory. Versatile equipment has been developed in such a way that any arrangement of counter trays in coincidence and anti-coincidence up to sixfold can be made just by plugging the components together and making simple adjustments of one set of bias voltages. Each counter tray has a simple preamplifier which also partially quenches the counter. (Self-quenching counter tubes are used, but the quenching circuit is believed to prolong the life of the counters.) This is followed by a cathode follower stage with a low impedance output, so that the signal may be carried twenty feet or more by cable. It then goes through a pulse-shaping and discriminating circuit ending in a pulse about three microseconds long. This pulse is then fed into mixing stages (up to three-fold) by adding the signals at the grid of the mixing pentode rather than by the more conventional Rossi circuit. For higher orders of coincidence, the output of a mixing stage may be fed to further mixing stages or a Rossi circuit.

From here it is fed to scaler circuits. The scaler circuits are all of the binary type, built in units of two stages, four stages, and eight stages. The output of the scalers will operate telephone message registers or one circuit of an Esterline Angus twenty-pen operations recorder or both in parallel. All the circuits have been designed for continuous operation, and quite complicated arrangements have often been operated for months without adjustment.

The observatory is now equipped with about forty scalers, and about thirty double- and triple-coincidence units, mixing units, units for higher order coincidence or anti-coincidence arrangements. Counter trays with their preamplifiers are usually made to fit experimental arrangements as required.

Besides the investigations mentioned above, an investigation is in hand on the range spectrum of mesons at this observatory both by coincidence and anti-coincidence arrangements of counters. Delayed coincidence in which the meson is detected by its decay electron is also used.

Proportional counters were used in an experiment designed to look for highly ionizing particles in cosmic rays at sea-level. The results were negative; but they produced an interesting study of the statistical variations in the production of ions along the path of an ionizing particle. Two large high-pressure ionization chambers have been constructed which are being used for continuous intensity measurements and a study of bursts. Both photographic recording with an electrometer and a vibrating reed electrometer are being used with these.

Associated with this observatory is a cosmic ray station in the Canadian Arctic (geomagnetic latitude 83·0° N.) at one of the joint Canadian–American weather stations. Continuous measurements have been taken for about two years, and during the 1950–51 winter, a programme of work there was undertaken in which an accurate comparison of intensities and the spectral distribution of mesons were made. At present a watch is being kept there for the sudden increases in intensity associated with solar flares.

The staff of the group normally consists of three physicists on the National Research Council staff and three technicians. There is room for three post-doctorate Fellows; these fellowships are offered by the National Research Council of Canada to students of Ph.D. standing who wish to work in Canada for a period before taking a permanent post.

[1] Rose, D. C., *Can. J. Phys.*, **29**, 227 (1951).

DETERMINATION OF THE ABSOLUTE CONFIGURATION OF OPTICALLY ACTIVE COMPOUNDS BY MEANS OF X-RAYS

By Prof. J. M. BIJVOET, A. F. PEERDEMAN
AND
A. J. van BOMMEL
van 't Hoff Laboratory, University of Utrecht

J. H. VAN 'T HOFF extended the structural formulæ of organic chemistry to include spatial configuration ("La chimie dans l'espace" (1874), the aliphatic carbon atom with hydrogen or other atoms at the corners of a tetrahedron surrounding it). X-ray analysis has determined the exact configurations and the interatomic distances accurately to within a hundredth of an angstrom unit.

Optically active compounds are not superimposable and are the inverted image of each other. Now it is a remarkable fact that while all details of such configurations can be determined, it yet remained unsolved, whether model or inversion corresponds with a given—say the dextrorotatory—compound. Our present investigation was concerned with this question.

It is impossible to determine absolute configurations by chemical means, which show only the relationship between different structures. These relationships would not alter in any respect if every optically active compound should possess its inverted configuration. Absolute configurations—introduced for the sake of expressing relationship—were based on mere convention. Emil Fischer attributed the configuration of Fig. 2*b* to natural, dextrorotatory, tartaric acid—with an even chance that this choice would fit the real situation.

Of the physical methods of determining absolute configuration, the theoretical calculation of the rotatory power is the most obvious and that most

studied; hitherto, the results, however, have lacked conclusiveness. Recently, a discussion of the relation between crystal structure and face development has been put forward. As to the X-ray method, X-rays are not supposed to be able to determine absolute configuration as they measure the interatomic distances, which do not differ for model and inversion.

This condition may be illustrated by the simple schematic diffraction experiments indicated in Fig. 1. Compared with (*a*), the diffraction object in (*b*) has been inverted. The path (phase) differences for each pair of atoms involved in the same direction of diffraction (*p*) remains unchanged (except for sign); hence the resultant interference effect will be the same for both conditions. The removal of this equivalence is the essential point of the determination of absolute configuration by X-rays.

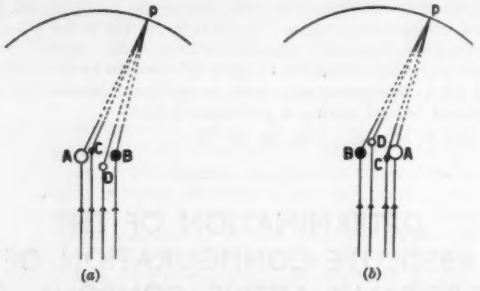


Fig. 1. Equal phase differences (except for sign) for model and inversion in the same direction of diffraction. By introducing a phase-lag in the scattering of one of the atoms, this equivalence is removed

A phase-lag can be introduced into the primary scattering process by one of the atoms[1], say atom A. This is achieved by using X-rays of a wave-length that just excites atom A. Again, for the conditions (*a*) and (*b*), compare the phase differences operative in the diffraction p. Consider the phase difference between the waves scattered by the atoms A and B. In (*a*) the characteristic phase-lag in the scattering of atom A is seen to be connected with the longer light path, in case (*b*) with the shorter. Hence, the total phase difference operative in the interference of the waves scattered by A and B will no longer be opposite, and the diffraction intensities will differ for these two conditions. (In the crystal diffraction, besides the inequality $I^a_{hkl} \neq I^b_{hkl}$ (*a* and *b* denoting the two optical antipodes) the following relation exists: $I^a_{hkl} = I^b_{\overline{hkl}}$. According to the latter relation, the films of optical antipodes do not differ in diffraction intensities, but only in their succession on Weissenberg diagrams with fixed rotation sense of the crystal.)

This difference of corresponding diffractions, which vanishes for X-rays of arbitrary wave-length, has been observed in the case of sodium rubidium tartrate using zirconium $K\alpha$ rays which just excite the rubidium atom[2]. It enabled us, analogous to the case discussed above, to decide between the diffracting model and its inversion. The result is that Emil Fischer's *convention*, which assigned the configuration of Fig. 2 to the dextrorotatory acid, *appears to answer to reality*.

Obviously, the agreement between conventional and real model then also embraces all compounds, the configurations of which—relative to tartaric acid

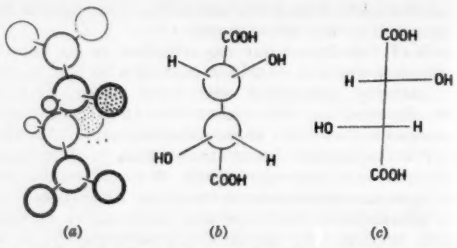


Fig. 2. Absolute configuration of natural dextrorotatory tartaric acid
a, As determined by X-rays in sodium rubidium tartrate.
b, In normalized configuration by rotating around single bonds.
c, In projection.

—have been determined. Details are given in ref. 2 and in a forthcoming paper in *Acta Crystallographica*. (A preliminary account was given by one of the authors (J. M. B.) at a conference in Pennsylvania State College in April 1950.)

The question of nomenclature is beyond the scope of our investigation. Absolute configuration determined, the standard substance for which hitherto a configuration had to be assumed becomes a redundant concept. The problem of nomenclature now concerns given configurations, and requires a notation which denotes these configurations in an unambiguous and if possible self-explanatory way. The usual notations like D_g or L_g for dextrorotatory tartaric acid, based on chemical relations, seems rather unsatisfactory from the latter point of view. For a recent study of the problem reference should be made to the literature[3].

We wish to thank the Netherlands Organization for Pure Research (Z.W.O.) for its support of this investigation.

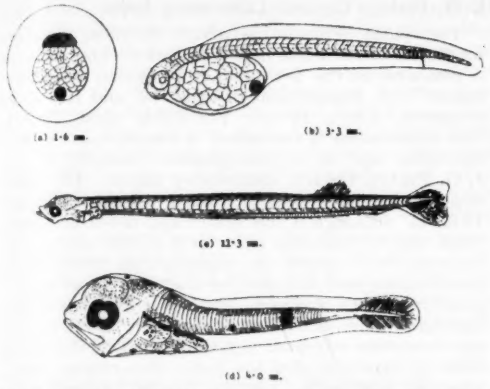
[1] von Laue, M., *Ann. Physik*, **50**, 33 (1916). Coster, D., Knol, K. S., and Prins, J., *Z. Phys.*, **63**, 345 (1930). See also James, R. W., "The Optical Principles of the Diffraction of X-Rays", chapter 4 (1948).
[2] Bijvoet, J. M., *Proc. Roy. Acad. Amsterdam*, **52**, 313 (1949). Peerdeman, A. F., van Bommel, A. J., and Bijvoet, J. M., *ibid.*, B, **54**, 16 (1951).
[3] Cahn, R. S., and Ingold, C. K., *J. Chem. Soc.*, 612 (1951).

BREEDING GROUND OF PILCHARDS OFF THE COAST OF SOUTH-WEST AFRICA

By Dr. T. J. HART
National Institute of Oceanography
AND
N. B. MARSHALL
British Museum (Natural History)

DURING the recent whale-marking voyage of the R.R.S. *William Scoresby* (Lieut.-Commander A. F. Macfie), notable concentrations were found of the eggs and larvæ of the pilchard (*Sardinops sagax*) off the coast of South-West Africa. In view of the large scale of the modern South African pilchard fishery, this indication of the breeding ground, hitherto unknown, is likely to be of considerable importance.

The R.R.S. *William Scoresby* is equipped for making oceanographical surveys, and it had been arranged that during her passages between whaling grounds in the Atlantic and Indian Oceans the



Early stages in the life-history of the pilchard, *Sardinops sagax* (Jenyns), and the stockfish, *Merluccius capensis* Castelnau, from South-West African waters: (*a*) developing egg, 1·6 mm.; (*b*) a newly hatched larva, 3·3 mm.; and (*c*) a post-larva of the pilchard, 11·3 mm.; (*d*) post-larva of the stockfish, 4·0 mm.

opportunity should be taken to make detailed studies of the plankton and water conditions in the Benguela Current. The main purpose was to obtain a closer understanding of the exceptional organic productivity of the region, and to compare its main features with those of the still more productive region in the Peru Current, for the investigation of which the same vessel was used in 1931 under the Discovery Committee. The work off the African coast was mainly between 19° and 29° S., and two surveys were made, in March and September 1950.

During the sorting of the material collected during the first survey, large catches of clupeoid eggs, larvæ and post-larvæ, have been noted, and they have been identified as belonging to *Sardinops sagax* (Jenyns) (see diagram). The preliminary examination gives a clear indication that spawning took place within twenty-five sea-miles of the coast in depths of 50–150 metres throughout the area surveyed, but mainly between 22° and 26° S. A few post-larvæ were taken in deeper net-hauls, but none in the deeper, warmer water outside the continental shelf. The eggs were found where the mean temperatures of the upper 50 m. of water were less than 17·5° C., the heaviest catches being made where the mean temperature was between 13° and 14·5° C. This suggests a close parallel between the spawning temperature of this species and the limits established for the California pilchard (*S. cœruleus*), for which the inclusive temperature range was found to be 12·5°–16·5° C. The season (early autumn) in which the South African pilchard was found to be spawning is not remarkable, since closely related clupeoid fishes in Australian and European waters spawn at opposite seasons near the extremes of their geographical distributions. Information about the spawning in other seasons off the African coast is limited to the R.R.S. *William Scoresby's* second survey (spring), and the preliminary examination of the catches indicates that very little spawning had taken place and only at two stations close inshore.

A quantitative comparison between the abundance of eggs and larval stages taken off the African coast with observations on related species in other regions is rather uncertain, because of the difference and variability of the filtering power of the nets and sampling procedures that have been used; but a conservative estimate suggests that the richest hauls off the African coast in early autumn represent spawning concentrations considerably greater than those reported in European and Californian waters. It seems probable, therefore, that the spawning of *S. sagax* may have been near its climax in early autumn.

During the sorting of the plankton collections, some association was noted between the occurrence of the pilchard eggs and the increasing abundance of *Fragilaria* ribbons among the diatoms; also with the occurrence of *Cladocera* among the smaller crustaceans and of polychæte and lamellibranch post-larvæ. But these features are part of the increasingly neritic facies of the community as land is approached, and are apparent at other seasons. The catches of Cumacea (mainly *Iphinoë* sp.) corresponded very closely with the pilchard egg numbers, and these particularly, being comparatively large and easily recognized, might prove to be useful pointers to the presence of pilchard eggs.

The eggs and young stages of other commercially important fishes were taken, particularly of the stockfish (*Merluccius capensis*), which is very like the European hake. Since ripe and running stockfish were trawled in early autumn, it is not surprising that larvæ and post-larvæ were taken during this season (see drawings), but they also formed part of the spring plankton. Evidently the spawning season is prolonged, as with other members of this genus.

The material is not yet completely sorted, and it is likely to be some time before its implications are fully understood and a detailed account prepared.

NEWS and VIEWS

Presidency of the British Association, 1952: Prof. A. V. Hill, C.H., F.R.S.

THE election of Prof. A. V. Hill to the presidency for 1952 of the British Association for the Advancement of Science, in succession to H.R.H. the Duke of Edinburgh, is timely in view of the fact that at the end of this year Prof. Hill resigns from the Foulerton professorship of the Royal Society—a chair which he has held with such distinction since 1925. Prof. Hill was Brackenbury professor of physiology in the University of Manchester during 1920–23, after which he was appointed Jodrell professor of physiology in University College, London. In 1925 he became Foulerton professor of the Royal Society, working at University College. When, in 1925, he ceased to be Jodrell professor in University College, the University of London appointed him honorary professor. His honorary professorship also expires at the end of this year under the age-limit, and the University has now conferred upon him the title of emeritus professor. Prof. Hill intends to continue his researches at University College, London, accommodation having been placed at his disposal through the courtesy of Prof. G. L. Brown, the present Jodrell professor. Also at the end of this year, the Biophysics Research Unit at University College, of which Prof. Hill has been such a distinguished head and which hitherto was financed by the Royal Society and the Rockefeller

Foundation, will come under the financial charge of the College and will be raised to the status of a Department, with Dr. B. Katz, at present reader in experimental physiology, as professor.

Prof. Hill was awarded the Nobel Prize for Physiology and Medicine in 1922, and the Copley Medal of the Royal Society in 1948. During 1935–45 he was a secretary of the Royal Society and during 1945–46 he was the Society's foreign secretary. This is not the place to deal with Prof. Hill's world-famed researches in physiology, especially biophysics, or to chronicle his many activities in connexion with scientific advancement and education, except perhaps to mention that he was member of Parliament representing the University of Cambridge during 1940–45.

Endeavour Prizes at the British Association

On August 9 at the British Association meeting in Edinburgh, H.R.H. the Duke of Edinburgh presented prizes to the winners in a scientific essay competition for young scientific workers less than twenty-five years of age. This was the second year of the competition, which was sponsored by *Endeavour*, a quarterly review of science published by Imperial Chemical Industries, Ltd. Altogether seventy-six essays were submitted, and the prize-winners (their ages shown in brackets) were as follows: *First Prize of Fifty Guineas*, B. C. Kilkenny (23), of Beaumont College, Old Windsor and New College, Oxford, and now a research student in the Physical Chemical Laboratory, Oxford, for an essay on "Biological Effects of Radiation"; *Second Prize of Twenty-Five Guineas*, J. H. Pantin (21) (the son of Dr. C. E. A. Pantin, president this year of the Zoology Section of the British Association), of Oriel College, Oxford, for an essay on "Animal Locomotion"; *Third Prize of Ten Guineas*, P. G. Garner (24), of Cambridgeshire High School for Boys and King's College, London, and now a research student in physical chemistry at King's College, for an essay on "Chromatography and its Possibilities"; *Special Prize of Five Guineas* (for a competitor under eighteen years of age), M. J. Sheridan (17), of Hornsey County School, for an essay on "Seaweeds and their Uses".

Use of Fuel and Power Resources

Mr. P. J. Noel-Baker, Minister of Fuel and Power, has appointed a committee to consider the use of resources of fuel and power in Great Britain. The terms of reference are: "In view of the growing demands for all forms of fuel and power arising from full employment and the rearmament programme, to consider whether any further steps can be taken to promote the best use of our fuel and power resources, having regard to present and prospective requirements and in the light of technical developments". The membership of the committee is as follows: Viscount Ridley, member of the former Fuel and Power Advisory Council (*chairman*); Mr. Lincoln Evans, general secretary of the Iron and Steel Trades Confederation; Mr. N. W. Gardiner, technical director of Huntley and Palmers, Ltd.; Sir Claude Gibb, chairman and managing director of C. A. Parsons and Co., Ltd.; Prof. W. R. Hawthorne, professor of applied thermodynamics, University of Cambridge; Prof. W. A. Lewis, professor of political economy, University of Manchester; Mrs. M. Mackintosh, tutor in sociology at Bedford College, University of London; and Miss M. R. Schofield, housing manager of Stoke Newington Borough Council.

I. G. Farben Central Laboratory Index

Technical information about chemical products marketed under trade names in Europe and America is available at the Technical Information and Documents Unit, Department of Scientific and Industrial Research, Lacon House, Theobalds Road, W.C.1. The information is contained in twenty-nine reels of microfilm and is a photographic facsimile of the I. G. Farben Central Laboratory Index. The index appears to have been compiled during the years 1933–43, although a few additional notes are dated 1946, and it comprises more than 57,000 cards. The information is given in alphabetical order under trade names and includes the chemical name of each product or its analysis, and its constitution and application. In addition, information about patents and literature reference is given. Most of the entries refer to dyestuffs, but the index also covers resins, plastics, detergents, wetting agents, waterproofing and emulsifying agents, textile assistants, rubber accelerators, cellulose esters, synthetic rubber, oil additives, tannins, insecticides, solvents, pharmaceutical products and other commodities. The index can be inspected at the Technical Information and Documents Unit (Chancery 4411) by appointment and no charge is made for inspection. Photo copies of entries may be ordered and purchased.

Odours of Minerals

An informative article on "The Odours of Minerals", by Dr. W. McCartney, has appeared in *The International Perfumer* (No. 3, 1951, pp. 7–10). The odours attributed to some solid bodies, which, having negligible vapour pressures, might be expected to be entirely odourless, are by no means imaginary, and have attracted attention since as early as 1798, when Fourcroy discussed the odours of metals. Later, in 1898, a study of the odours of a number of metals was described by Ayrton at a meeting of the British Association at Bristol; he concluded that the odours were not those of the metals themselves but of impurities and substances produced, for example, by human breath and perspiration. Later work has substantiated Ayrton's conclusions, and has demonstrated that metal surfaces can adsorb and tenaciously retain traces of organic compounds such as mercaptans and thio-ethers. Another aspect of the same phenomenon concerns natural minerals. The odours emitted on striking white pebbles and other minerals such as quartz, agate and flint have been found to be caused by organic impurities. These impurities may be present as bituminous inclusions or may be derived from dust, lichens, moss or algæ, or from earth or mud; but contamination by organic matter, imparted by contact with human hands, is one of the chief causes of such odours. Brief contact with human skin imparts this property; the impurity is very tenaciously retained, and can only be removed by such drastic treatment as ignition at a dull red heat; washing with alkali or brushing seem to be ineffective. Other types of mineral odours, the odours sometimes noticed by mountaineers in the neighbourhood of landslides and avalanches, may be caused by the frictional heating of rock matter containing traces of pyrites or vegetable matter.

Eelworm Pests of Mushrooms

A paper, "Eelworms (Nematodes) as Pests of Mushrooms", by Charles A. Thomas and George H. Mitchell, is reprinted in Bull. No. 22 of the Mushroom

Growers' Association (January 1951; obtainable from the Association at Yaxley, Peterborough; 5s.). It describes how eelworms belonging to the groups *Ditylenchus* and *Rhabditis* may damage mushroom beds by the destruction of mycelium, leaving bare patches, and by the distribution of disease-producing bacteria. They may be carried to the beds initially on the casing soil, but also persist between crops upon the bed boards. Satisfactory control has been obtained by heating the houses uniformly, after filling, to 140° F. for a day or more. Steaming the house for several hours after the temperature begins to fall helps with the sterilization of boarding. The temperature should not reach 150° F. or moulds may bring another kind of damage. Formaldehyde treatment is ineffective as a control, and chloropicrin has given variable results.

Prehistoric Cave Paintings in South Africa

THE March issue of the *South African Archæological Bulletin* contains an article by J. R. Harding on his investigations at a rock-shelter site about six miles to the east of Bethlehem, Orange Free State. Some poor paintings occur, the most recent apparently being the figure of a Bush woman. The industries excavated range from Smithfield *C* without pottery to levels where pottery appears, to a latest Smithfield *C* with strong Bantu influence, with even some evidence of true Bushman occupation. It seems scarcely likely that any of the paintings are older than the industries unearthed, and none of these can be assigned to a very remote period. The paintings themselves are poor specimens and not well drawn.

Entomological Testing Methods

IN 1948, the Entomology Subcommittee of the Chemical - Biological Coordination Center, U.S. National Research Council, obtained information on insecticide-testing from numerous laboratories and the results were distributed to participants. The Subcommittee planned to continue this successful survey. Recently, after discussions with the American Association of Economic Entomologists and others, it was decided that a book on testing methods in entomology would be more useful and, in April 1951, Dr. Harold H. Shepard, U.S. Department of Agriculture, was appointed editor. The book will include toxicological and screening methods used by entomologists in the United States and other countries and will contain descriptions of methods detailed enough to permit them to be duplicated. It will be published by the National Research Council and sold at cost price. Those who wish to participate in this project by furnishing descriptions of the test methods which they use should apply for forms to Dr. Raimon L. Beard, Chairman, Entomology Subcommittee, Chemical–Biological Coordination Center, National Research Council, 2101 Constitution Avenue, Washington 25, D.C.

Cartography of the Antarctic

RECENT American and Norwegian work, as well as the discoveries of the German Swabenland expedition in 1939, are incorporated in a new map of the Antarctic by H. P. Kosack in *Petermanns Mitteilungen* (95, No. 2; 1951). The map, which is in blue and brown, is on a scale of 1 : 11,250,000, and shows surface and bathymetrical relief in 1,000-m. form lines. Notes in the margin give the location of the British, Argentine, Chilean and French stations. Names in the main follow the English usage; but there are many new German names in New Swabenland and American names in Marie Byrd Land and in the Ellsworth plateau. Accompanying this map is one on the scale of 1 : 4,000,000 of New Swabenland and adjoining territories between Coats Land and Princess Ragnhild Coast. A full and critical list of cartographical sources is given. Another article in the same number of this German publication, "Zur Frageder Namengebung in der Antarktis", by Dr. J. Georgi, gives the sources of German names in the Antarctic map with a full list of such names. This is most useful and should be done for all names in the Antarctic before there are no members left of the various expeditions who can supply the information. Already the origin of several German names of the 'nineties are untraceable.

The Chillingham Cattle

FOR thirty years prior to 1947 the strength of the famous herd of cattle in the park at Chillingham Castle in Northumberland had been fairly constant at about 35–40 head. After the severe winter of 1947, thirteen survived, of which eight were cows, five were bulls and none was young. For eighteen months or so no calf was born, and it was feared that the king bull might have become infertile; it was thought that this bull would have to be destroyed to save the herd from extinction. Fortunately, two bull calves arrived and, later, four heifers. The herd now consists of three bulls, seven cows, two bull calves and four heifer cows and now seems to be re-establishing itself. To help in the preservation of this valuable herd, which has almost certainly been at Chillingham Park since 1240, in 1939 an Association was formed. Those who wish to view the herd and apply for membership of the Association should write to the Secretary, Chillingham Wild Cattle Association, Ltd., Estate Office, Chillingham, Alnwick, Northumberland, for further information.

World Metallurgical Congress

A WORLD Metallurgical Congress will be held in Detroit, Michigan, during October 14–19. It is expected that more than five hundred individuals from some twenty different countries will attend, in addition to American metallurgists. The Congress has the full support of the Economic Cooperation Administration of Washington, D.C. A technical assistance programme covering visitors from E.C.A. countries has been established at the request of the Organization for European Economic Cooperation. Foreign visitors are expected to arrive about September 15 and will spend approximately five weeks in the United States. During the first four, they will be divided into eight groups participating in a series of study tours to industrial, government and educational institutions to observe at first hand the scientific, industrial and educational advances that have taken place in the United States during the past few years. Dr. Zay Jeffries, of Pittsfield, Mass., retired vice-president of the General Electric Company, and a past president of the American Society for Metals, has been appointed director general of the Congress. Early in the Congress a comprehensive summary of raw materials of the world as they relate to the metal industry will be presented. Visiting authorities from various countries will discuss problems of conservation, utilization and substitution of strategic metals. The industrial study tours planned in connexion with the Congress are being arranged in eight categories of

the metal industry : steel-making and refining ; non-ferrous refining, rolling and fabrication (copper, brass, bronze, aluminium, magnesium) ; ferrous rolling, forging and hot work in steel mills and heavy industry ; stamping, cold work, machining and finishing in lighter industry ; heat treatment ; welding and joining ; inspection and testing ; and research, engineering societies and universities. Information concerning the World Metallurgical Congress can be obtained from the Secretary, American Society of Metals, 7301 Euclid Avenue, Cleveland, Ohio.

Symposium at Delft on Abrasion and Wear

A SYMPOSIUM on abrasion and wear, organized by Rubber-Stichting on the occasion of the opening of a new building at Delft, will be held during November 14–15. The first day will be devoted to general aspects of the subject, including problems connected with friction and lubrication, and the second day to the applied side, that is, the abrasion and wear of metals, plastics, rubber and other materials. The symposium will be international in scope, in that a number of foreign workers will be participating, some of whom will be reading papers ; the official languages of the symposium will be English and French. In conjunction with the meeting an exhibition of apparatus for measuring abrasion and wear has been arranged. Admittance to the symposium will be free. Further details can be obtained from the secretary of the organizing committee, Dr. H. C. J. de Decker, c/o Rubber-Stichting, P.O. Box 66, Delft.

Colonial Service Appointments

THE following appointments in the Colonial Service have recently been announced : A. K. Briant (senior agricultural officer, Zanzibar), director of agriculture, Zanzibar ; J. W. D. Goodban (agricultural officer, Nigeria), director of agriculture, British Honduras ; C. E. Johnson (agricultural officer, Northern Rhodesia), chief agricultural officer, Northern Rhodesia ; C. J. MacK. Krige (senior agricultural officer, Northern Rhodesia), chief agricultural officer, Northern Rhodesia ; J. Wright, whose appointment as assistant director of agriculture, Nigeria, was previously announced, re-transferred to his former post of deputy director of agriculture, Jamaica ; M. E. Dommen (senior assistant conservator of forests, Nigeria), conservator of forests, Nigeria ; W. Crocker (senior assistant, Department of Agriculture, Sarawak), assistant agricultural officer, Sarawak ; R. A. Sutton (chemist, Government Chemist Department, Tanganyika), geo-chemist, Geological Survey Department, Tanganyika ; F. B. Brown, agricultural officer, Federation of Malaya ; C. Purvis, geneticist, Oil Palm Research Station, Nigeria ; L. P. Adams, staff surveyor, Kenya ; Lieut.-Colonel J. D. Daly, veterinary officer, Federation of Malaya ; Dr. R. A. Webb, soil scientist, Gambia.

Announcements

LORD BRUCE OF MELBOURNE, formerly Australian High Commissioner in London, has been elected the first chancellor of the Australian National University, Canberra.

DR. E. U. CONDON, director of the U.S. National Bureau of Standards, is resigning as from September 30. It is reported that Dr. Condon is to join the Corning Glass Company as a technical director.

PROF. N. V. SIDGWICK, formerly professor of and reader in chemistry in the University of Oxford, has been elected an honorary life member of the Faraday Society in recognition of his outstanding services to physical chemistry and to the Society.

SIR ARCHIBALD GILL, engineer-in-chief of the Post Office, is to retire on October 1 ; he will be succeeded by Dr. W. G. Radley, who is at present a deputy engineer-in-chief.

MR. E. K. INALL, who until recently was a member of the research staff of Associated Electrical Industries, Ltd., Aldermaston Court, Berks, has been appointed a Research Fellow of the Australian National University, Canberra. He will work in the Department of Nuclear Physics under the direction of Prof. E. W. Titterton.

IN order to ensure that the fullest use is made, in the interests of the aircraft industry in Great Britain, of all published scientific and technical information concerning aeronautics, Aslib is establishing an Aeronautical Information Study Group, the inaugural meeting of which is to be held on September 27 at the Royal Aircraft Establishment, South Farnborough, Hants. All those interested in the formation of such a Group should write, not later than September 10, to Mr. Leslie Wilson, director of Aslib, at 4 Palace Gate, London, W.8.

THE Research Fund of the Chemical Society provides grants for the assistance of research in all branches of chemistry. About £700 per annum is available, the income being derived from a donation of the Worshipful Company of Goldsmiths, from the Perkin Memorial Fund, and from other sources. Applications for grants will be considered in November next and should be submitted on the appropriate form, to be obtained from the General Secretary, Chemical Society, Burlington House, Piccadilly, London, W.1, not later than November 1, 1951.

THE fifth congress of the International Scientific Film Association will be held in the Municipal Museum, The Hague, during September 15–22. At the congress the general assembly of the Association will take place, together with meetings of the permanent committees dealing with medical, research, technical and industrial films, as well as a Festival of Scientific Films. Further information can be obtained from the Secretary, Scientific Film Association, 4 Great Russell Street, London, W.C.1.

THE following lectures of the Royal Aeronautical Society have recently been announced. The thirty-ninth Wilbur Wright Memorial Lecture will be given by A. E. Raymond, of the Douglas Aircraft Corporation, California, at 6 p.m. on September 10 at the Royal Institution, 21 Albemarle Street, London, W.1, his subject being "The Well-Tempered Aircraft". The seventh British Commonwealth and Empire Lecture will be given by Air Vice-Marshal Sir L. M. Isitt, of New Zealand, at 6 p.m. on October 4 at the Institution of Civil Engineers, Great George Street, London, S.W.1, his subject being "Air Transport in New Zealand and the South Pacific". Further details can be obtained from the secretary of the Society, A. M. Ballantyne, at 4 Hamilton Place, London, W.1.

ERRATUM.—In *Nature* of June 30, p. 1060, it is stated that the chairmen of the four Groups of the Physical Society are for the period 1950–51 ; this should read 1951–52. Further, the chairman of the Colour Group for this period is Dr. T. Vickerstaff.

THERMAL CONDUCTIVITY OF DIELECTRIC CRYSTALS: THE 'UMKLAPP' PROCESS

By Dr. R. BERMAN, Prof. F. E. SIMON, C.B.E., F.R.S., and Dr. J. WILKS
Clarendon Laboratory, Oxford

BECAUSE of the experimental difficulties in obtaining temperatures over the whole range below 100° K., measurements on thermal conductivity have not hitherto been sufficiently extensive to reveal all the characteristics of the conductivity/temperature relationship. We have recently measured the thermal conductivities of several very different dielectric crystals over a wide range of temperatures. Fig. 1 shows the conductivities of single crystals of quartz, sapphire[1], and diamond[2], and Fig. 2 gives values for crystals of solid helium at different densities measured over a smaller temperature range[3]. (We may note that our results on diamond, made on a large, well-cut specimen, confirm Eucken's belief that his own results[4] were unreliable.) It can be seen that all the crystals referred to in Fig. 1 behave similarly and all have a pronounced maximum; more recent measurements have shown that there is also a maximum in the curves for helium at lower temperatures. These results suggest that the thermal conductivities of all pure dielectric crystals behave in the same general way and enable us to discuss the underlying internal processes.

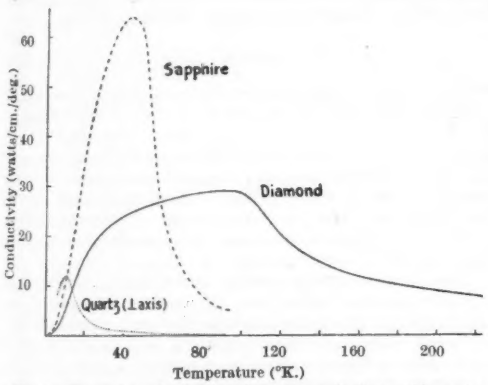


Fig. 1. Thermal conductivities of quartz, synthetic sapphire and diamond

Some years ago, de Haas and Biermasz[5] made measurements on crystals of quartz, potassium chloride and potassium bromide at low temperatures, and together with Casimir[6] demonstrated that in the region where the conductivity falls with temperature the flow of thermal energy is limited by its being scattered at the walls of the crystal. This is the so-called 'size effect' which results in the measured thermal conductivity becoming proportional to the smallest dimension of the specimen and to the cube of the absolute temperature. As a result of this discovery, attention was directed away from the region where the conductivity rises as the temperature falls, and no systematic measurements were made there. While the present results give some additional data on size-effect phenomena, which will be published elsewhere, their main interest is in throwing some light on the intrinsic properties of bulk crystals.

The foundations of all discussions on thermal conductivity were laid down by Debye[7], who treated the atomic vibrations of a solid as an assembly of elastic waves in a continuum. He derived the general formula for conductivity:

$$\varkappa = \tfrac{1}{3}lCv, \qquad (1)$$

where v is the group velocity of the waves (the velocity of sound) and C the thermal capacity per unit volume. The remaining quantity, l, the mean free path, is the distance which the waves travel before being attenuated by a factor e. He showed that this expression leads to the observed relation $\varkappa \propto 1/T$ when the temperature is high enough for C to be taken as constant; but it gives no explanation of the behaviour at lower temperatures.

Later, Peierls[8] treated a crystal as a lattice rather than as a continuum; at high temperatures his theory also predicts that the thermal conductivity varies as $1/T$; but at low temperatures it leads to a relation of the form $\varkappa = QT^{\nu}\exp(\theta/2T)$, where Q is some constant, ν is of order unity and θ is the Debye specific heat parameter. (Provided that the conductivity is not limited by size effect, this implies that it should approach infinity at absolute zero.) As the processes responsible for the form of this law are not widely understood, it may be useful to discuss them in some detail.

In a large pure crystal free from impurities, cracks and strains in its structure, the scattering of thermal waves will only be caused by collisions between the waves themselves. Peierls treated these by quantizing the sound waves into quanta of vibration or phonons

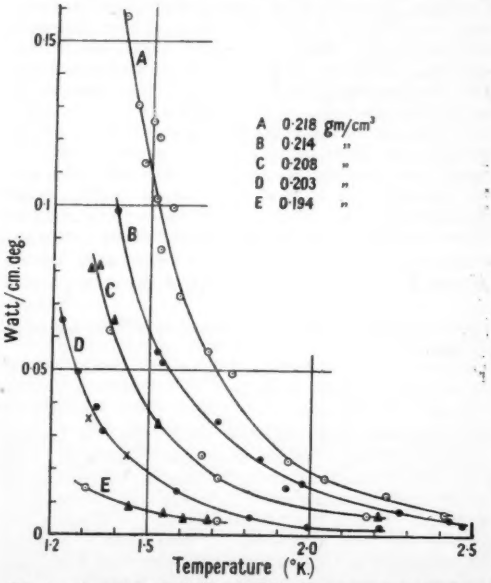


Fig. 2. Thermal conductivity of solid helium at constant density

and then finding the conditions for the phonons to interact. It turns out that the only collisions of importance are three-phonon processes in which two phonons coalesce to give one, or one splits up to give two. Such collisions are shown to be possible if:

$$\omega_1 + \omega_2 = \omega_3, \tag{2}$$

$$\overline{K}_1 + \overline{K}_2 = \overline{K}_3, \tag{3}$$

where the ω's are the angular frequencies and the $\overline{K}$'s the wave numbers associated with the phonons. These conditions correspond to the conservation laws for energy and momentum. Equation (2) states that after a collision the resulting wave or waves are still carrying as much energy as before, while equation (3) implies that this energy is still flowing in the same direction. Hence, no impedance to the flow of energy is introduced by these collisions; that is, they do not give rise to any thermal resistance.

Peierls also showed that collisions are possible if

$$\omega_1 + \omega_2 = \omega_3, \tag{2}$$

$$\overline{K}_1 + \overline{K}_2 = \overline{K}_3 + \frac{2\pi\bar{\varepsilon}}{a}, \tag{4}$$

where a is the lattice constant and $\bar{\varepsilon}$ is a unit vector which can take up any one of six orientations parallel to the axes of the crystal (for simplicity Peierls treats a cubic lattice). To put it colloquially, equation (4) means that for some collisions between phonons 'momentum is not conserved'. More precisely, we can say that though equation (2) implies that there is no energy change resulting from collision, equation (4) states that the direction of flow of this energy will be altered. Although there is some correlation between the initial and final directions of flow (as given by equation (4)), $\bar{\varepsilon}$ can take up any one of six directions, so that the final result is much the same as if the waves were scattered at random. Hence such collisions will impede the flow of energy and give rise to a thermal resistance.

Peierls has named this type of collision an 'Umklapp' process, which can perhaps best be translated as a 'flap-over' process; at a collision the wave number vector 'flaps over' and takes up a new position. Umklapp processes, or U-processes, result from the periodicity of the lattice: they would not occur, for example, in a continuum. They come about because of the possibility of interference effects between the phonons and the lattice by which the lattice can transfer momentum between itself and the phonons. It is as if phonons can suffer Bragg reflexions from the lattice; and equation (4) may be taken to mean that because the lattice is perturbed by the mode $\overline{K}_3$, conditions are favourable for the phonon $\overline{K}_1$ to suffer Bragg reflexion into the phonon $\overline{K}_2$.

If a U-process is to take place at all, we see from (4) that

$$\overline{K}_1 + \overline{K}_2 \geqslant \frac{2\pi\bar{\varepsilon}}{a}.$$

This implies that phonons must have a certain minimum energy before they can 'umklapp', and Peierls shows that, as a rough criterion, this minimum energy may be taken as $k\theta/2$, where k is Boltzmann's constant. Hence the probability of U-collisions will contain the term $\exp(-\theta/2T)$; and when T is small the variation of this exponential term will mask any temperature-dependent term of the form T^r.

Although Peierls derives the thermal conductivity without using the concept of mean free path, it seems a convenient parameter with which to characterize a given scattering process. Therefore we introduce λ, which we define as the mean distance travelled by phonons between collisions which produce scattering. Since the waves in Debye's theory have now been replaced by quanta, we rewrite equation (1) as

$$\varkappa = \tfrac{1}{3}\lambda C v \tag{5}$$

by analogy with the kinetic theory of gases. In particular, for single crystals free from impurities, cracks and mosaic structure, the mean free path is limited only by U-collisions, so that:

$$\varkappa = \tfrac{1}{3}\lambda_U C v, \tag{6}$$

where λ_U is the mean free path for U-collisions. It is, of course, important to note that this concept of mean free path is a more complex one than that met with in gas kinetics, because the probability of U-processes depends on the polarization of the colliding phonons as well as on their energy.

Values of λ_U for several crystals, including solid helium, have been calculated from equation (6) by using the measured values of the thermal conductivity and specific heat; the values of the velocity of sound are derived from the corresponding specific heat by Debye's theory. Fig. 3 shows these values plotted against θ/T for artificial sapphire, diamond and solid helium, θ being obtained from specific heat measurements. It is clear that to a fair approximation, over a considerable range, we may write

$$\lambda_U = A\exp(\theta/bT), \tag{7}$$

where A is a constant depending on the crystal and b has a value slightly greater than 2 (2·3 for helium, 2·7 for diamond, 2·1 for sapphire). The fact that we obtain this relation both supports Peierls' theory and also suggests that any thermal resistance due to imperfections in the crystals is small compared with the resistance due to U-processes. Unfortunately, it is not possible to calculate the values of A to be expected on Peierls' theory.

The measurements which have been made on crystals of solid helium are of particular interest as the density of the helium can be changed considerably by using quite moderate pressures, and this makes a very big difference to the thermal conductivity. Although the conductivities at different densities differ greatly (Fig. 2), values of λ_U which have been calculated at temperature intervals of 0·1° for all five densities lie approximately on the same curve. Thus, in helium the number of U-collisions is primarily a function only of θ/T.

We may note here that exact agreement with Peierls' theory cannot be expected, because the behaviour of real crystals only approximates to that of Debye-type models. For example, the specific heat of solid helium at these low temperatures does not vary exactly as T^3, and so there is no unique value of θ corresponding to each density. The values of θ used in Fig. 3 were obtained from the known specific heat by using Debye's formula $C = 464\,(T/\theta)^3$ cal./gm. atom/degree. This is certainly justifiable as a first approximation, since the variation in θ due to the density changes is about ten times as great as the variations due to the temperature changes. The position with sapphire and quartz is also complicated, because these have two or more atoms of different

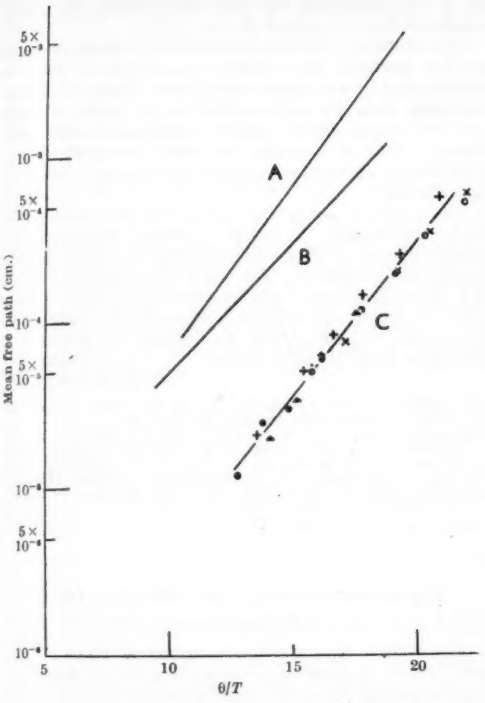


Fig. 3. Mean free path for U-collisions as a function of θ/T. A: synthetic sapphire ($\theta \simeq 980$); B: diamond ($\theta \simeq 1{,}840$); C: solid helium (θ, 22–35). For solid helium the densities are: 0·218 (×); 0·214 (○); 0·208 (+); 0·203 (▲); 0·194 (●) gm./cm.³

mass in the unit cell and so again they cannot conform to Debye's theory. Quartz, too, is difficult to treat, as the crystal is strongly anisotropic and the conductivities in directions along, and perpendicular to, the axis differ by a factor of about 2; so quartz has not been included in Fig. 3. Even so, the general behaviour of these thermal conductivities is similar to that in other crystals, as may be seen from Fig. 1.

The picture we have presented so far has to some extent been over-simplified; for example, Peierls[8] pointed out that phonons corresponding to transverse and longitudinal waves behave differently in collision processes. Klemens[9] has recently treated the statistical equilibrium of phonons and shown that it is also necessary to consider collisions which conserve momentum because, while they do not contribute directly to the thermal resistance, they may change the polarization of a phonon and thus render it more susceptible to a U-collision. He derives an expression for the thermal conductivity which is of the same form as Peierls' expression, save that he gives $\nu = 1$. As the term $\exp(\theta/bT)$ is very sensitive to the value of b, it is unfortunately impossible to verify that the power of T in the equation is really 1 and not, say, 2 or zero, particularly as none of the crystals is theoretically ideal. Obviously it would be desirable to make more measurements on crystals with a simple structure; but in practice there are not many suitable crystals available, particularly as the conductivity of ionic crystals is very sensitive to the effect of scattering by impurities, which would mask U-type collisions.

It is interesting to note that for each crystal the maximum in the thermal conductivity occurs at a temperature of about $\theta/20$. At first sight this maximum might be expected where λ_U first becomes limited by the size of the crystal. As the specimens were in the form of rods a few millimetres in diameter, this criterion gives $\lambda \sim 0{\cdot}1$ cm. Therefore, since λ_U is given primarily by θ/T, it is to be expected that the maximum would occur at a particular value of this parameter. Although we find this to be so, the value of the mean free path calculated by substituting the value of the maximum conductivity into equation (5) is an order of magnitude less than the size of the crystals. Klemens, in his more detailed treatment[9], has shown that in the region near the maximum where both U-processes and scattering by the walls play an appreciable part, some such effect is to be expected; but it does not appear sufficient to account for the large reduction in mean free path which is observed.

There is, in addition, the possibility that the mean free path may also be limited by departures from complete regularity in the crystal lattice[10]; the effect of one particular form of mosaic structure has been treated by Pomeranchuk[11]. It seems that it would introduce a thermal resistance which would again account for the reduction of the conductivity near the maximum, so that not until the lowest temperatures, where even this resistance is negligible, should the mean free path become comparable with the smallest dimension of the crystal. This is in agreement with our experiments and those of de Haas and Biermasz. We may note that this reduction in the magnitude of the mean free path near the maximum does not have much effect on the position of the maximum, as λ_U varies very rapidly in this neighbourhood. In particular, the very flat top on the curve for diamond suggests that some such process as this may be taking place.

Values of λ_U for high temperatures are not given in Fig. 3, because the exponential is not varying so rapidly in this region and, owing to the other temperature-dependent terms derived by a more detailed treatment, the simple relation (7) no longer holds. Those measurements which we have made at higher temperatures ($\theta/T < 10$) suggest that, at very high temperatures ($\theta/T \to 0$), λ_U tends to a value of a few angstroms, a distance of the order of the atomic spacing. This is in agreement with other work done at relatively high temperatures. For example, in potassium chloride[12], one of several substances for which data on single crystals are available, we find that the mean free path at 0° C. ($\theta/T = 0{\cdot}8$) is only a small number of lattice spacings.

Over the range of θ/T between 10 and the maximum, we may write $\lambda_U = A\exp(\theta/bT)$, where A varies from 6×10^{-8} cm. for solid helium to $1{\cdot}4 \times 10^{-6}$ cm. for diamond. In order to relate the constant A to some property of the crystal, we recall (Debye[7], Peierls[8]) that if the forces between the atoms in a crystal were perfectly harmonic, there would be no interactions between the various modes of vibration (that is, no collisions between phonons); thermal equilibrium could never be established and it would be impossible to define a thermal conductivity. Interactions between modes, or collisions of phonons, are only possible if the forces are anharmonic, and it is reasonable to suppose that the greater the anharmonicity the greater the number of collisions. Of course, once collisions occur, their temperature-dependence includes the exponential term; but their

absolute number is given by A and must depend in some way on the anharmonicity of the inter-atomic forces. In principle, it is possible to derive A by perturbation theory from the anharmonicity as measured by the second pressure derivative in the equation of state; for example, a solution of a comparatively simple problem of this type has been given by Van Vleck[13]. Unfortunately, the difficulties of solving the relevant equations for the general problem of thermal conductivity appear to be very great; also it would not be easy to get the necessary experimental data for crystals as hard as sapphire. The density of helium, however, may be changed quite easily, and we hope that it may be possible to correlate its thermal conductivity with measurements on its compressibility.

To sum up, we may say that the thermal conductivities of pure dielectric crystals follow a common pattern. At sufficiently high temperatures they vary as $1/T$; then at lower temperatures the conductivities increase more rapidly until they are limited by size effect and fall off towards zero. The shape of the conductivity/temperature curve is to a fair approximation determined only by θ, the specific heat parameter. It is, of course, true that the values of the conductivity in the U-region also depend on the constant A, but as may be seen from Fig. 3 this lies within relatively narrow limits. Thus, while the magnitudes of the thermal conductivities of the different crystals vary greatly (the lowest value measured was 2×10^{-2} watt units for helium at 2° K. and the highest 60 watt units for sapphire at 50° K.), they can all be deduced, at least to an order of magnitude, once the specific heat parameter is known.

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THEORETICAL ASPECTS OF SUPERCONDUCTIVITY

Crystal Structure and Superconductivity

THE prediction that it is the interaction between electrons and lattice vibrations[1] which is responsible for the establishment of the superconductive state has been verified by the discovery of the isotope effect[2]. Theoretically, for a metal to be a superconductor a condition regarding the strength of this interaction has to be fulfilled. This condition requires (see ref. 1*a*, equations (3.19) and (6.8)) that a parameter which depends on the number ν of free electrons per atom must exceed a certain value. This parameter is proportional to $(4\nu)^{1/3}$ if $4\nu < 1$ and proportional to $1/(4\nu)^{1/3}$ if $4\nu > 1$. On the assumption that other quantities entering into it are independent of ν, an optimum for the attainment of superconductivity is reached if $\nu = 1/4$.

The number ν of free electrons of a metal depends on its Brillouin zone structure, which in turn is determined by the lattice structure. Since each zone contains sites for two electrons per unit volume, $\nu = 1/4$ means either nearly empty, or nearly full, zones. This is actually the case for most superconductors, as was remarked some time ago by Born and Cheng[3].

The result $\nu = 1/4$ was derived on the assumption of free electrons. It holds, however, whenever the energy of the electrons is proportional to the square of the wave-number. For some structures this may not be so, and thus a modification of the exact value of ν is required, although the above qualitative statement regarding the occupation of zones will probably hold in most cases. [June 9.

H. FRÖHLICH

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Superconductivity and Effective Mass of Electrons

SOME time ago, Bardeen[1] suggested that a very small effective mass of electrons would lead to superconductivity. Later he found that the theory of the interaction between electrons and lattice vibrations[2] actually yields such a small effective mass[3]. I wish to show here, however, that small effective mass alone leads always to normal behaviour. Even though a state with non-penetrating magnetic field may be relatively stable[3], the normal state if it exists has always the lower Gibbs free energy, provided that no other than magnetic interaction between electrons is considered. Although the small effective mass is no doubt an important property, it is imperative in the presence of a magnetic field to consider the change of interaction between electrons and the vibrational field in order to obtain superconductivity, as has been shown recently[4].

To prove that without this the normal state exists (and hence is stable), let us review the results of the Landau–Peierls theory[5] of the diamagnetism of a gas of free electrons. Here the energy increase due to the presence of an external homogeneous magnetic field H_0 is calculated, based on a Hamiltonian:

$$\mathcal{H}_0 = \sum_k (\mathbf{p}_k - \frac{e}{c}\mathbf{A})^2/2m^*, \qquad (1)$$

where m^* is effective mass, $\mathbf{A}$ is the vector potential and the sum extends over all electrons. The result per unit volume is found to be

$$\frac{1}{2} |\chi_0| (\text{curl } \mathbf{A})^2, \qquad (2)$$

where the quantity $|\chi_0|$ is expressed in terms of various parameters. In particular, $|\chi_0| \to \infty$ if $m^* \to 0$. On the other hand, if χ is the magnetic susceptibility of a substance, its energy increases by $\frac{1}{2}|\chi|H_0^2$ if brought into the field, provided that $|\chi| \ll 1$. Hence, in this case χ_0 is equal to the magnetic susceptibility χ. Now since the permeability

$$\mu = 1 + 4\pi\chi = 1 - 4\pi|\chi| \qquad (3)$$

must always be positive, then $|\chi| < 1/4\pi$.

It would be wrong to apply the result $\chi \simeq \chi_0$ to the case $m^* \to 0$ and thus derive a contradiction of the condition $|\chi| < 1/4\pi$. For in this case the Hamiltonian is

$$\mathcal{H} = \sum_k (\mathbf{p}_k - \frac{e}{c}\mathbf{A}_k)^2/2m^* + U_{int}; \qquad (4)$$

where U_{int} represents the magnetic interaction energy between electrons, and $\mathbf{A}_k$ is the macroscopic vector potential at the position of the k-th electron diminished by the contribution to $\mathbf{A}_k$ of this electron. This latter is negligible so long as the radius of the classical orbit is large compared with the distance between neighbouring electrons. Hence,

$$\text{curl } \mathbf{A} = \mathbf{B} = \mu\mathbf{H}, \qquad (5)$$

where $\mathbf{H}$ is the macroscopic field. Using (4), (2) and (5), the energy increase per unit volume is now given by

$$U = \frac{1}{2}|\chi_0|\mathbf{B}^2 + \bar{U}_{int}, \qquad (6)$$

where the bar indicates formation of the expectation value.

Expression (6) has to be equated to the energy increase U_m (per unit volume) obtained with the help of the macroscopic theory in terms of χ. Both U_m and U_{int} depend on shape, but the resultant value of χ is, of course, independent of shape. For this reason the simplest procedure is to consider a diamagnetic slab between the poles of a permanent magnet. The value of $\mathbf{B}$ is then the same as in the absence of the slab. Hence $U_{int} = 0$ and $U_m = (HB - B^2)/(8\pi)$. This expression must be equal to (6), which now is equal to $\frac{1}{2}|\chi_0|B^2$. Thus, using (3) and (5), we find

$$\left(\frac{1}{\mu} - 1\right)\frac{1}{8\pi} = \frac{1}{2}|\chi_0| \quad \text{or} \quad \chi = \mu\chi_0. \qquad (7)$$

Hence,

$$|\chi| = \frac{|\chi_0|}{1 + 4\pi|\chi_0|} < \frac{1}{4\pi}, \qquad (8)$$

so that no contradiction to the condition $\mu > 0$ can occur, that is, the normal state exists.

Finally, to show that the result is actually independent of shape, consider a diamagnetic needle parallel to the direction of field. In this case $U_m = \frac{1}{2}|\chi|H^2$, because H is now equal to the field in the absence of the body. U_{int} is the self-energy per unit volume of a needle-shaped magnet with polarization $(B - H)/(4\pi)$; that is, $U_{int} = (B - H)^2/(8\pi)$. Equating U_m to U leads to the previous result (7). [June 9.

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Specific Heat of Metals at Low Temperatures

THE interaction in a metal between the lattice vibrations and the conduction electrons has been shown by Fröhlich[1] to lead, if sufficiently strong, to the superconductive state. If too weak for this, it can lead to modifications in the properties of the normal state at low temperatures. In suitable circumstances, for example, this S-interaction can lead to a peak in the specific heat at a few degrees absolute.

It has been shown by Fröhlich that if a certain factor, f, depending on the strength of the interaction, is greater than unity, the ordinary spherical distribution of electrons in momentum space is not the one of lowest energy at the absolute zero of temperature. For normal metals, $f < 1$ and the spherical distribution is, in fact, stable.

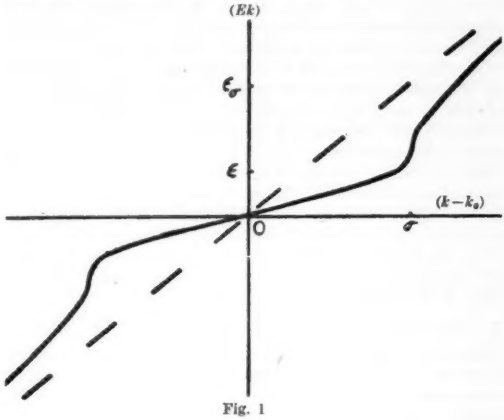

Fig. 1

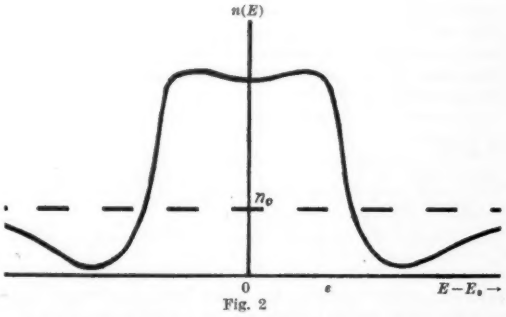

Fig. 2

The energy of an electron near the surface of the distribution at absolute zero is shown as a function of wave number in Fig. 1 for a possible normal state. The corresponding energy-level density is shown in Fig. 2. The broken lines correspond to the case $f = 0$ (or neglect of the S-interaction).

It is intended to discuss the properties of the superconducting state in a later communication, so we confine ourselves here to the case $f < 1$. The energy-level density, $n(E_0)$ at E_0, the edge of the filled region at the absolute zero, is then given by

$$\frac{n(E_0)}{n_0} = \frac{1}{1 - f} \quad (f < 1). \qquad (1)$$

The specific heat as a function of temperature will have the form shown in Fig. 3 for several values of f,

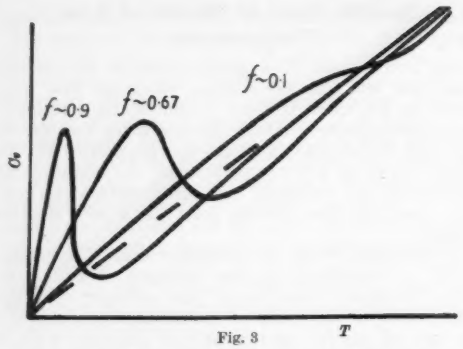

Fig. 3

the ratio of the slopes at $T = 0$ and $T = \infty$ being given by (1). The total energy due to the peak is, of course, of the same order of magnitude as the energy-difference of a superconductor in the normal and superconducting states at absolute zero.

Anomalous peaks of this energy have been observed in the specific heats of sodium[2] and beryllium[3], at about 7° and 11° respectively. The experimental results, however, do not show the linear increase at small temperatures given in Fig. 3, and it is thought that this may indicate an inadequacy in the description of states near the ground-state, a question which arises also in our investigation of the thermal properties of the superconducting state itself.

It is simple to estimate the energy content, ΔE, of the anomalous hump in the specific heat. From Fig. 2, and equation (1),

$$\Delta E \sim \tfrac{1}{2}\,(n(E_0) - n_0)\,\varepsilon^2 = \tfrac{1}{2}\,\{f/(1-f)\}n_0\,\varepsilon^2.$$

Now $\varepsilon = (1-f)\,\varepsilon_\sigma$, where $\varepsilon_\sigma = 2(\sigma/k_0)\zeta = kT_\sigma$, say, ζ being the Fermi energy, and if σ_0 is the wave number of an electron moving with the velocity of sound, $(\sigma_0/\sigma)^3 = 4\nu$ (if $4\nu > 1$), where ν is the number of free electrons per atom (see equation (3.4) of ref. 1). From equation (2.7) of the same paper, we then see that $T_\sigma = \theta_D$, the Debye temperature. In the free-electron approximation we have, for one gram molecule :

$$kn_0 = \tfrac{3}{2}\,\nu R\zeta^{-1},$$

so that

$$\Delta E \sim \tfrac{3}{4}\nu f(1-f)\,RkT_\sigma{}^2\zeta^{-1}. \qquad (2)$$

The peak containing this energy occurs at a temperature about $T' = \frac{1}{2}(1-f)T_\sigma$.

Using values appropriate to sodium, $\theta_D = 150°$, $\zeta = 3{\cdot}1$ eV., and $\nu = 1$, we must take $f \simeq 0{\cdot}9$ to make $T' \simeq 7°$ K., and (2) then gives $\Delta E \sim 0{\cdot}11$ calories, about equal to the value estimated from the experimental curve published by Pickard and Simon.

In the case of beryllium, $\theta_D \simeq 1{,}000°$, but the free-electron approximation cannot readily be applied since there are two zones nearly filled. It would be expected in this case that $T_\sigma \ll \theta_D$, but an estimate of ΔE on the lines of that for sodium would have little meaning.

My thanks are due to Prof. H. Fröhlich for many stimulating discussions, and to the Australian National University for the award of a travelling scholarship.

[June 9.

M. J. Buckingham

Department of Theoretical Physics,
University of Liverpool.

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A METHOD FOR MAKING ACCURATELY REPRODUCIBLE MASKS OF THE HUGGINS TYPE

By BARTON HOWELL, CARL J. CHRISTENSEN
AND
DAN McLACHLAN, jun.
Departments of Physics and Ceramics, University of Utah

IN 1929 Bragg[1] described a method for the photographic summation of Fourier series by the addition of the proper patterns of light and dark bands. Huggins[2] in 1941 showed how this method could be improved in accuracy and speed by the use of a previously prepared set of masks, and in 1944 Huggins[3] published a number of illustrations of projected crystal structures produced by means of his masks. In Huggins's first paper[2], he described the photographic procedure that was followed in producing a sinusoidal transparency across the masks perpendicular to the light and dark bands. This procedure involved making what was called mask *A*, from which a second mask *B* was made, before producing the final masks for the Fourier summations. These two preliminary masks were necessary in order to compensate for the non-linearity in response of photographic material to light ; and also because of this lack of linearity, no set of finished masks could be used as a master in making further copies of the masks.

The present investigation is based on the knowledge that much of the modern work in photographic reproduction is accomplished by using a master which has only two tone values, white and black, and in which the visual illusion of the various shades of grey is produced by the relative areas occupied by the discrete portions of white and black. This variation in area is usually accomplished by varying the size of the regularly spaced dots. However, in view of the difficulty in getting a perfectly sinusoidal distribution of sizes of black dots across a master figure, it was thought best to make the black areas them-

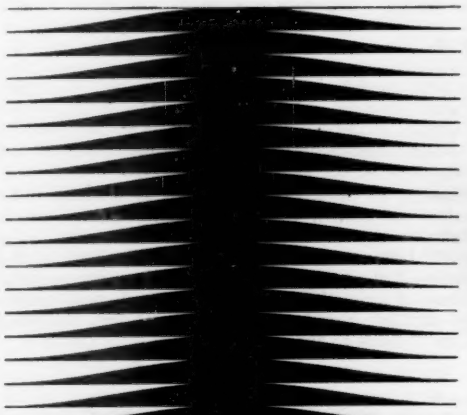

Fig. 1. Unit of pattern for assembling the master figures

selves vary in shape sinusoidally. Fig. 1 shows a unit of area used to build up the master figure. Each black streak in Fig. 1 obeys the equation

$$\omega = \omega_0 \left(1 + \sin \frac{2\pi n x}{L}\right),$$

where ω is the width at any distance, x, from the left-hand edge, ω_0 is the maximum width, and L is the length of the streak.

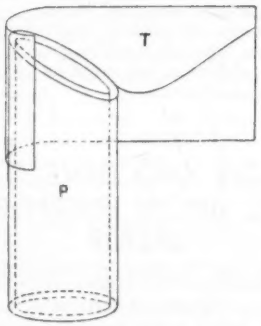

Fig. 2. Manner of making a template for drawing sine curves

Since it is very difficult to plot, from trigonometrical tables, these sinusoidal curves sufficiently accurately for this work, a template was made by the procedure shown in Fig. 2. A piece of 5-mill shim brass T is wrapped about a pipe P with a bevelled end. The inside of the shim brass is marked against the bevelled end of the pipe with a sharp metal scribe. When the brass is unwrapped from the pipe, a sine curve is apparent; and by cutting the brass on the scribed line, the template is ready for making curves and filling in with ink to produce Fig. 1.

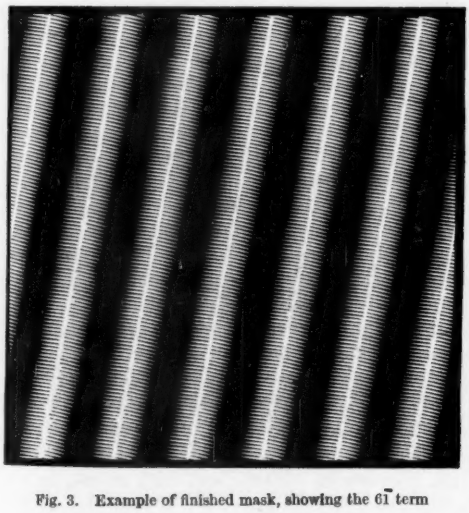

Fig. 3. Example of finished mask, showing the $6\bar{1}$ term

Fig. 3 shows the $6\bar{1}$ mask. Masks up to h and k values of 10 have been prepared and are available through the Universal Microfilming Corporation (277 6th Avenue, Salt Lake City 3, Utah). When these masks are used in the usual manner or in the multiple projector[4], the details of the white and black streaks are lost and a sinusoidal effect of dark and light bands is produced by out-of-focus projection.

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APPLIED ELECTRONICS

THE exhibition of electronic devices which was held at the Manchester College of Technology during the last week of July was the sixth, and by far the largest, of the annual displays organized by the North-West Branch of the Institution of Electronics. The Exhibition, planned as part of the City's contribution to the Festival of Britain activities, included a number of special features in addition to the usual trade displays of production models of electronic equipment. The research section, in which applications of electronics were on show in the 'string and sealing-wax' stage, was particularly interesting; and there were a number of 'guest' exhibits which, in addition to being excellent examples of applied electronics, were also of high entertainment value. Film shows and a series of lectures on specific problems were also part of the programme.

In the space allowed, it would be impossible to describe all the exhibits which were of special interest, and it must be pointed out that the particular devices selected for mention here are not necessarily of greater merit than the rest but are simply those which had the greatest personal appeal to the writer.

Of the 'guest' exhibits, perhaps the most impressive was the 'Electrone' displayed by the John Compton Organ Co., Ltd. This attracted a lot of attention as it was a smaller version of the instrument to be installed in the Manchester Free Trade Hall. The console of the instrument is completely orthodox; the stops, pistons and manuals are identical with those to be found on a modern pipe organ, and in fact no additional knowledge or skill is required by the player than would be required for playing an equivalent pipe organ. The tones are generated electrostatically from capacity changes produced by rotating wave-form electrodes. Harmonics are not produced separately but in groups, so that wide varieties of tone can be produced with a minimum of circuits. Valves are used only for straight amplification. Although the organ occupies a very small amount of floor space, it has a tonal quality which is remarkably close to that of a good pipe organ. Specially designed circuits provide delays (both before and after the depression of a key) which simulate the speaking characteristics of actual pipes with remarkable accuracy, and the instrument has none of the characteristics usually associated with electronic musical instruments.

Ferranti, Ltd. (Edinburgh), displayed a slow-speed relay computer designed to demonstrate the technique of automatic solution of problems in logic. Complex logical problems can, when broken down into a number of 'rules' or logical restrictions, be solved in a very short time even by this slow-speed machine. Two models were demonstrated. One obtained the solution by trying all possible combinations of the variables in turn; this model would give all the possible solutions to a given problem. The other does not try all combinations but is made to converge

on a correct solution; this form is much more rapid, can deal with a greater number of variables but gives only one of the possible answers.

Also among the 'guest' exhibits was an amateur radio station in full operation, complete with home-made radio transmitters and receivers and a television receiver.

In the research section, Imperial Chemical Industries (Dyestuffs Division), Ltd., displayed a light-flux integrator. A photo-cell charges a condenser which triggers a flip-flop circuit at a given charge-level. This operates a counter, discharges the condenser and resets the circuit for the next count. A range of instruments involving transformer-type electromagnetic displacement gauges were on show. One such device measured the rate of wetting of a textile sample in water by recording the movements of a torsion balance, to which the sample was attached, as the water was absorbed.

The Electrical Engineering Department of the Manchester College of Technology displayed apparatus illustrating both research carried out in the College, and devices used in teaching. In the former category was an apparatus for indicating the rate of change of mains-frequency directly on a single dial, and designed for use in power stations. A useful device for teaching purposes was a harmonic synthesizer in which one could see, directly on a cathode-ray tube screen, the effect of adding together various proportions of different harmonics.

In the trade section there was a bewildering variety of equipments, all beautifully finished and a large proportion of them actually in operation.

Ferranti, Ltd. (Hollinwood), demonstrated their mercury–argon crater lamps, which give a light output directly proportional to the current passing through the lamp. These have wide application in sound-film recording and picture transmission, as the light can be modulated at frequencies up to 12,000 c./s. Among other interesting items was a new flat-faced television picture-tube with a 14-in. diagonal rectangular screen.

Fielden (Electronics), Ltd., demonstrated a yarn-irregularity meter. The instrument effectively determines the mass of a centimetre length of yarn, instantaneously present in the gap of a special condenser head, in terms of its dielectric properties. The instrument then notes the irregularities, integrates them over a predetermined period and presents the result, on a single dial, as the average irregularity expressed as a percentage of the average mass of the sample. The reading is quite steady and independent of the speed at which the sample is passing through the instrument.

One of the most interesting exhibits on the stand of Marconi Instruments, Ltd., was an audiometer assembly, specially designed for measuring the hearing acuity of young children. The instrument incorporates a standard pure-tone audiometer. The portion of the instrument visible to the child is brightly decorated in nursery style and consists of a loud-speaker and a 'peep-show' arrangement. This is so devised that a brightly coloured picture becomes visible when the child presses a button, provided that a test signal is being applied to the loud-speaker.

The Metropolitan-Vickers Electrical Co., Ltd., displayed their high-speed, recurrent-wave-form monitor which gives, on a cathode-ray tube screen, a trace of a recurrent wave-form with frequency components up to 300 Mc./s. In any one cycle, the instantaneous amplitude at some one point of the wave-form is measured. On successive recurrences, the instantaneous value at other points is recorded and after about 200 cycles a complete picture of the wave is available.

Mullard, Ltd., had on view a number of important additions to their range of valves, including a new disk-seal ultra-high-frequency triode, with a new type of cathode which permits closer spacing of electrodes —with consequent higher maximum frequency of operation—than has hitherto been obtainable, a series of sub-miniature valves and the first members of their range of image-converter tubes.

The Exhibition Committee deserves special congratulations on the organization, which, at any rate to an outside observer, appeared to be particularly free from technical hitches. C. A. Taylor

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RESEARCH AND DEVELOPMENT IN THE SIMON ENGINEERING GROUP

By Dr. W. RHEINALLT THOMAS
Director of Research

THE year 1908 saw the establishment of the first Simon Laboratory for examining and testing the materials used and produced in the coke ovens and coal-washing plant then being built by the firm. In 1912 tests associated with the manufacture of sulphuric acid were also undertaken. In the period between the two World Wars, the Laboratory was enlarged on three occasions to cater for advances in the design of existing plant and the introduction of new activities, which now include the production of power stations, turbine gears and a wide variety of chemical plant and mechanical and pneumatic handling machinery. Each department had also set up its own small teams of research workers and technical development engineers.

Tremendous expansion followed the Second World War, as demonstrated by the fact that orders to the value of £75 million have been taken at home and abroad, and it became clear that existing arrangements for testing, research and development were inadequate. Plans were drawn up to meet the situation, and building began in mid-1949.

On July 3 last, Sir Henry Tizard opened the new buildings, consisting of a central research block, a testing wing housing what was known as the Laboratory and now forming part of the Research Department, and the first of two development wings. These new buildings are almost entirely devoted to the research and development interests of Simon-Carves, Ltd. The Henry Simon companies forming the other half of the Simon Engineering Group, and with very different fields of activity, have entirely independent facilities for research and development, although there is the closest co-operation, particularly where problems of mutual interest are concerned.

The central research building, 159 ft. long, 45 ft. wide and 45 ft. high, contains four research laboratories, microscope, balance and dark rooms, as well as sections for testing metals and refractory and building materials. The library, information room and offices occupy the central portion of the first floor.

The testing wing on two floors is 105 ft. long, 55 ft. wide and 25 ft. high, and is specially designed to cater, on a much enlarged scale, for the activities of

the old laboratory. The chemical work is carried out on the first floor, where four laboratories and ancillary rooms are provided. The ground floor contains six laboratories for the mechanical and physical testing of coal and coke, as well as a large workshop capable of dealing with all research and development requirements.

The development wing is a single-story building 165 ft. long, 55 ft. wide and 45 ft. high, and is devoted to experimental pilot plant on coal washing, coke ovens and pneumatic handling machinery. Until such time as the second wing is erected, space has been allocated in the existing wing to the chemical and power-plant development sections.

The main lines of activity fall into four broad classes: chemical analysis and materials testing; research; information; technical development. The division is arbitrary but convenient; overlapping is inevitable and only brief descriptions are given here of a few features of the work.

Before any plant is designed, exhaustive laboratory investigations are carried out on the materials to be used and produced, so as to provide the designer with data that will enable him to predict accurately the suitability of the raw materials and guarantee the performance of the plant.

For coal-washing plant design, information is given on the separation of coal and shale and of the fine coal and tailings as well as for the treatment of water for re-circulation. The assessment of coal for use in coke ovens involves proximate and ultimate analyses, determinations of the swelling properties, the yields of coke and by-products and analysis of the gases evolved. For boilers and power plant using either stoker or pulverized fuel, the calorific and ash fusion values are also determined.

The refractory materials employed in coke ovens are subjected to stringent tests for completeness of firing and strength under load at high temperatures and for resistance to abrasion and to sudden changes of temperature. Building materials undergo rigorous tests and analyses prior to use. A number of mechanical, physical and chemical tests are also carried out on the metals used in plant construction.

The general chemical analyses cover a wide range of organic and inorganic compounds as well as complex ores. Forty-four by-products of coal are analysed as a matter of routine. In connexion with the manufacture of sulphuric acid, catalysts, pyrites and the finished acid are examined, and such problems as treatment of waste acids and gases and phenol recovery from effluents form part of the programme.

To meet the needs for testing facilities on sites, a self-contained mobile laboratory has been fitted up and, by means of interchangeable cabinets, equipment can be quickly changed to permit tests on every type of plant built.

Research on a centralized as opposed to a departmental basis is of recent origin. Some of the problems embrace the activities of the organization as a whole; others are mainly of sectional interest. Reference is made to one of each type.

One field of common practical interest concerns small particles which are involved in the collection, extraction and disposal of industrial mists and dusts; the combustion of pulverized fuel and sulphur-bearing ores; sedimentation and studies in magnetization for dense medium washing.

The restriction of imports of raw sulphur for sulphuric acid manufacture has made it urgently necessary to devise means of purification and recovery of sulphur from alternative sources. The fields of investigation cover the filtration of molten sulphur, the flash roasting of iron pyrites, recovery from waste gases and spent liquors, and removal of hydrogen sulphide from town's gas.

The information section comprises a library and an information staff dealing mainly at present with the scientific and technical needs of the organization. By virtue of its activities it will possess an over-all generalized picture of the whole field of interest rather than a specialized knowledge of part of it.

The three main contracting departments in the organization are the coke-oven and coal-washing department and the power and chemical plant departments, and each has its own technical development sections. Work, hitherto, has been largely carried out on full-scale industrial plant. With the advent of the new wing, however, experiments on the pilot-plant stage will be carried out at first for rationalizing the design of existing plant and later in applying fundamental data to the design of new plant.

The new wing houses a complete dense medium coal-washing plant to one-third full scale, in which up to 25 tons of coal per hour can be treated, and effective separation of coal and shale differing only slightly in density is achieved. From trials on this plant and from the results of the associated laboratory tests, it is possible to erect full-scale plant of guaranteed performance. It will also be used for improving performance and for trying out new ideas. A small-scale self-contained coke oven has also been installed, and the results obtained can be translated to full-scale practice. An integrating radiometer establishes the combustion characteristics of domestic coke.

A pilot distillation plant in process of erection represents development of a new process where an entirely new design of fractionating column promises high efficiency in small volume.

The development sections of the power plant and chemical plant departments await the erection of the second development wing. In the meantime their work continues to be done largely on actual plant; but they have been allocated space temporarily in the existing wing. A test assembly of axial cyclones for gas cleaning has been erected, and at a later stage pilot plant for work on electrostatic precipitation will be installed. The chemical plant section is also co-operating with the British Iron and Steel Research Association in developing a method of recovering sulphuric acid from spent pickle liquor at steelworks. Among the main problems which the power-plant development section proposes to examine in detail are the behaviour and characteristics of pulverized fuel, the treatment of carry-over in steam and the expanding of tubes into drums and headers.

Recruitment of staff for the research department is proceeding and the ultimate establishment proposed will total 55, consisting of the director of research, twelve graduates of varying degrees of seniority, twenty-seven laboratory assistants, ten junior assistants and an administrative staff of five.

Each technical development section has its own staff headed by a senior scientific man. The coke oven and washer department has a team of six graduates, two senior and two junior assistants as well as a team for plant supervision and maintenance. The power-plant section has four graduates and one senior assistant, and the chemical plant section two graduates. Increases will be made when the second development wing is erected.

FACTORS CONCERNED IN FERTILITY OF MAMMALS

THE Society for the Study of Fertility held its second annual Conference on Fertility at Girton College, Cambridge, on June 20 and 21. There were four scientific sessions. The effects of experimental lesions of the hypothalamus in female rats on their œstrous cycles and mating behaviour have been studied by Miss H. M. Bruce and Dr. G. C. Kennedy (National Institute for Medical Research). No specific effects from such experimental lesions were seen on the cycles, whether the operation was followed by the development of obesity or not. However, in those rats which became obese, regardless of whether or no normal cycles continued, mating and pregnancy never occurred. Of ten animals in which obesity did not follow operation, only two mated. All the controls mated. Hypothalamic lesions produced in lactating rats did not always interfere with the continuation of lactation, even though obesity might supervene. The small, discrete, hypothalamic lesions did not result in gonadal atrophy in the rat. So far, only one sex effect could be localized in the hypothalamus, namely, a centre controlling the secretion of luteinizing hormone by the pituitary.

Mr. H. J. Cembrowicz (Ilminster) discussed the fertility-levels of bulls at an artificial insemination centre. Using as an index of conception the non-occurrence of œstrus in the three months following an insemination, it was found that there had been a rise in the conception-rate from 51 to 69 per cent between 1944 and 1950. During the same period, there had been a nearly five-fold increase in the number of inseminations per year, a six-fold increase in the number of inseminations per bull, and a seven-fold increase in the dilution of the semen used for insemination. Although semen production shows differences between breeds, with improved technique these become much less. Unlike the experience of the Milk Marketing Board, at his centre there has been no fall in conception-rate with increasing age of the bull, even when this reached eight and nine years. In the evaluation of the semen, motility has been found to be the best criterion. With different bulls, from one to three ejaculations per week can be obtained. It was found that 0·5 c.c. of diluted semen is just as effective a dose for insemination as 2 c.c.

Dr. Edmond J. Farris (Wistar Institute, Philadelphia) described his rat ovary hyperæmia test for the prediction of the day of ovulation in humans, and summarized some of the experimental work he has done to confirm its validity. He discussed its value, and the conclusions to be drawn from its use, in the practical handling of human infertility problems.

Dr. Nancy Laughton (University of Birmingham) described the bacteriological findings in cervical swabs taken from two groups of women, one showing positive and the other negative post-coital tests. (This work was done in conjunction with a study, reported by Miss Dorothy N. Shotton (of the Women's Hospital, Birmingham), on the cervical factor in human fertility.) The most striking feature was the absence of pathogenic organisms in all except one case from each of the two groups (this was *B. coli* in both instances). She had isolated from several patients of both groups a hitherto undescribed organism which is a small Gram-positive pleomorphic bacillus, 0·7 μ in diameter and 1–3 μ in length. It is culturally delicate and shows a rudimentary branching habit. From its morphology and cultural characteristics, which she detailed, it was concluded that it belongs to the order Actinomycetales. She gave it the provisional name *Corynebacterium cervicis*.

Experiments on the effect of thyroid hormone and of thiouracil on spermatogenesis in mice, rabbits and rams were described by Dr. M. Maqsood (Cambridge). Thiouracil interferes with the development of the germinal epithelium and decreases the number of interstitial cells. Thyro-protein, on the other hand, speeds up maturation of the testis, so long as the dose remains within the physiological range. In rams, thyroxin-treatment prevents the usual summer decline in spermatogenesis and improves the seminal quality generally. Thyroxin given to rabbits with previously poor records of semen production improves the seminal quality in all cases. Administration for forty-four weeks had no deleterious effect on the testes, whereas administration of thiouracil for a similar period led to complete testicular atrophy.

Dr. B. P. Wiesner and Prof. John Yudkin (King's College of Household and Domestic Science, London) described their experiments on the results of feeding a purified diet containing the known vitamin supplements to rats. They found that the interval from pairing to parturition is, in general, lengthened as compared with that of the controls fed on a stock diet; but most striking was the almost invariable death of the new-born young, in an emaciated condition, within two days of birth. Adding whole liver, and, to a lesser extent, vitamin B_{12}, corrected this effect, but only partially. It seems possible that the necessary nutritional factor (which they call 'R') may also be present in yeast. A method for the drying of liver at low temperature *in vacuo*, to produce a stable powder still containing factor R, was described.

Dr. T. Mann (Molteno Institute, Cambridge) described chemical methods of use in the analysis of semen. These include the estimation of fructose and citric acid and the demonstration of cytochrome by means of the microspectrometer. He also directed attention to the recent discovery in his laboratory of the presence of ergothioneine in seminal fluid. He was followed by Mrs. Clare Harvey (Exeter), who described the results of fructose and citric acid estimations in human semen. There are wide ranges of values for both these constituents, and no clear correlation with other seminal characteristics; though high fertility seems, in general, to be associated with relatively low fructose and high citric acid contents.

Dr. John MacLeod (Cornell University, New York) compared the seminal findings in 1,000 men of proved fertility with those in the husbands of 1,000 infertile marriages. His main conclusions are that sperm density, provided it exceeds 20 millions per ml., is of little significance; but high proportions of motile forms, with vigorous activity, is characteristic of the fertile males. There is no evident association of seminal abnormalities with repeated miscarriages.

Other papers were read by Dr. S. Bender (University of London) on the outcome of pregnancy in women previously sterile; Dr. Raymond G. Cross (Dublin) on tuberculous endometritis; Mr. Donald Young (Warrington) on surgery of the vas deferens; Dr. B. Sandler (Manchester) on the relationship of cervical hostility and asthenozoospermia in human sterility; and Dr. A. C. Crooke (Birmingham) on the effects of various adrenergic and cholinergic drugs on the gonadotrophin excretion of women with amenorrhœa.

INDIAN VETERINARY RESEARCH INSTITUTE

DIAMOND JUBILEE CELEBRATIONS

THE celebration of the diamond jubilee of the Indian Veterinary Research Institute, which was founded at Poona in 1889 and was transferred, in 1893, to Mukteswar, was held on March 11, 1951. Distinguished by the attendance of many workers from the different States of India, the gathering was addressed by the Hon. Shri K. M. Munshi, Minister for Food and Agriculture, who inaugurated, at the same gathering, the ninth meeting of the Animal Husbandry Wing of the Indian Board of Agriculture and Animal Husbandry.

India, said the Minister, possesses a quarter of the world's bovine population and also millions of sheep, goats, poultry and other animals; yet her production and consumption of milk are, perhaps, the lowest in the world. A sustained and multi-pronged effort to remedy this state of affairs is required and is being planned. Breeding, proper management and feeding of all kinds of livestock, and control of diseases from which they suffer, must be studied in a unified and comprehensive scheme which should be linked with India's "Grow More Food" campaign. The largest scheme ever presented by the Research Institute is, the Minister said, that for the eradication of rinderpest, which takes the heaviest toll of the lives of cattle and, in addition, debilitates and reduces the production of those beasts which survive. Everyone will endorse the Minister's hope that this scheme, to be carried out in collaboration with the Food and Agriculture Organization of the United Nations, will be financed and implemented soon. Meanwhile, a pilot scheme, designed to prepare the ground for the larger scheme, has been sanctioned by the Indian Council of Agricultural Research.

Discussing further the immense task of upgrading the millions of Indian cattle, the Minister commended the utilization, as part of the task, of artificial insemination. The central organization for the study of artificial insemination is housed in the Indian Veterinary Research Institute, and the Minister expressed the hope that this organization would be used to the fullest extent and that it would train the many personnel required for the Key-Village scheme.

The Key-Village scheme, on which the Minister asked the Animal Husbandry Wing to concentrate, has been drawn up by the Indian Council for Veterinary Research. It seeks to establish, all over India, a network of key-villages, the key-village being defined as a compact area consisting of one village or of a group of them, containing a total bovine population of five hundred. Each key-village will be surveyed to find out the distribution of cattle in it, its present productive capacity, the existing arrangements for the production and distribution of milk, the local supply of feeding stuffs and kindred matters. Bulls available in each area are to be examined and, if they are not satisfactory, they are to be castrated or removed and approved bulls are to be supplied. When the initial information has been obtained, the second phase of the scheme will introduce control of breeding, recording of milk production and other measures necessary for the improvement of the cattle. Still later it is hoped that the key-villages will operate as Government breeding farms helped by Government subsidies and supervision. Because there is an acute shortage of approved bulls in India, the possibilities of artificial insemination are already being studied, and the pilot scheme sponsored by the Indian Council of Veterinary Research is examining these possibilities in ten selected villages near Delhi.

Continuing a speech distinguished by its wide outlook and grasp of essentials, the Minister for Food and Agriculture expressed the view that the aim of breeding should be to produce a type of animal that can flourish under the conditions peculiar to its locality. The animal, he said, is fashioned by the type of husbandry used, by the kind of food and pasture available, by the factors in the environment which favour the occurrence of disease and by the climatic conditions generally. All these factors must be given due consideration. His speech concluded with a tribute to the Indian Veterinary Institute, the history of which, during sixty years of vigorous work, was outlined in an instructive address given to the gathering by the Institute's present director, Dr. S. Datta.

In a special jubilee issue of *Indian Farming*, which replaces the issue for March 1951, Dr. Datta describes the history of the Institute in greater detail. In this article, in fact, he gives a history of the development of veterinary science in India. Tracing its origin back to the men imported by the John Company in 1774 to look after stud farms, Dr. Datta describes the work of Moorcroft, Hallen and Cook and the appointment, in or about 1889, of the medical man, Dr. Lingard, as microscopist—and, soon after, bacteriologist—to the Government of India. To Lingard's work in the isolated surroundings of Mukteswar, Dr. Datta pays high tribute. The Indian Veterinary Research Institute should, he says, really be called the 'Lingard Institute of Animal Science'. He goes on to describe the work of Lingard's successors, paying just tributes to Holmes, Sir Leonard Rogers, Shilston, who unhappily fell a victim to glanders, Sir Percival Hartley, Macalister, Sheather, Pool, Doyle, J. T. Edwards, Cooper, Sir Frank Ware, Haddow, Macdonald and the last British director, Minett, who left the Institute, when the era of Indian independence began in 1947, to become animal husbandry commissioner to Pakistan.

For those who wish to know what 'Mukteswar' is now doing, there are, in this jubilee issue of *Indian Farming*, articles which describe the work going on in the Institute's various sections. The departments of pathology, bacteriology, parasitology, animal nutrition, biological products, poultry research and animal genetics are all confronted with varied and difficult problems. The section concerned with the training of workers is also an important one, because, as Dr. Datta points out, many senior workers have left Mukteswar to fill important posts elsewhere, and the need is great for experienced workers to carry out the extensive schemes that the Indian Government has in mind.

The future, it is clear, provides great opportunities for the Institute, and the solution of some of the difficult problems that confront it will provide fundamental knowledge that will be valuable to veterinarians all over the world. There is great and beneficent work to be done and a strong will to do it effectively. The good wishes of everyone interested in the welfare of man and his domesticated animals will go out to all those who are grappling with the complex problems that India now presents to her people.

G. LAPAGE

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Relative Abundances of Oxygen and Carbon Isotopes in Carbonate Rocks

The relative differences in the ratios oxygen-18 to oxygen-16 and carbon-13 to carbon-12 of some hundred and fifty carbonate rocks, including fourteen sedimentary limestones, ninety metamorphic limestones, twenty 'intrusive' carbonatites, twelve calcite crystals from Alpine clefts[1] and seven calcareous sinters have been measured. The aim of this investigation, which is being extended to include other carbonate rocks, is the accumulation of data that might lead to an interpretation of the isotopic differentiation in the carbonates on the basis of their geological history.

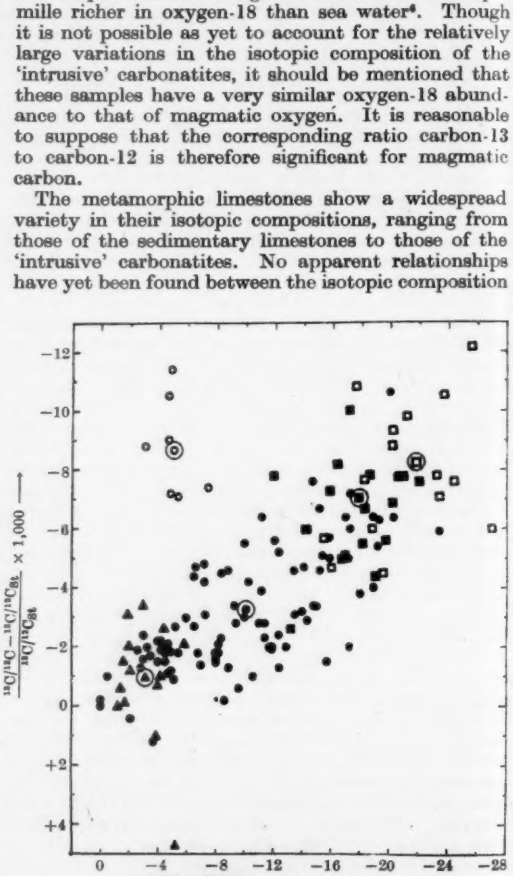
The determination of the relative abundances of the carbon and oxygen isotopes was carried out by means of a Consolidated-Nier double-collector mass spectrometer (type 21–201). The ratios oxygen-18 to oxygen-16 and carbon-13 to carbon-12 of each carbonate sample are reported relative to the corresponding quantities of an arbitrarily chosen standard limestone. The carbon dioxide samples necessary for this investigation were all prepared under the same conditions by decomposing the powdered rocks with 100 per cent phosphoric acid, according to a method developed by McCrea[2]. The results obtained in this manner are represented in the accompanying diagram. The deviations of the ratios oxygen-18 to oxygen-16 and carbon-13 to carbon-12 from those of the standard limestone (suffix St), given in parts per mille (‰), are used as x- and y-co-ordinates respectively. Negative figures thus indicate that there is less of the heavy isotope in the sample than in the standard. The carbon-13 to carbon-12 ratios are corrected for the variations in the oxygen-17 to oxygen-16 ratios, and the analyses were found to be consistent within about 1 per mille of the oxygen and carbon ratios.

The general character of the graph is at least partly explained by the fact that the isotopes of oxygen and carbon are fractionated in qualitatively the same way by most processes involving carbonate ions and carbon dioxide.

Considering the average isotopic composition of the different groups of carbonate rocks, it was found that the sedimentary limestones exhibit the highest abundances of the heavy isotopes. This can be understood from the low temperature of formation at which the oxygen-18 and carbon-13 in the carbonate are enriched by some 30 per mille and some 10 per mille respectively relative to the water containing carbon dioxide[3]. The scatter in the isotopic composition in this group may be attributed to local variations in temperature and isotopic composition of the water from which the carbonates were precipitated[3]. The calcareous sinters precipitated from fresh water are strikingly low in carbon-13. This is most probably due to the presence of dissolved carbon dioxide from decaying organic material. Such organic carbon is known to contain some 30 per mille less carbon-13 than the carbon dioxide in sea water[4].

On the other hand, since the isotopic fractionation between solid carbonate and its aqueous solution decreases with rising temperature of precipitation, we can see why the calcite crystals from Alpine clefts crystallized from hot solutions have the lowest abundances of heavy isotopes of all carbonates so far investigated. They contain, on the average, some 20 per mille less oxygen-18 than limestone precipitated from cold sea water. Since such limestone, as already mentioned, is enriched in oxygen-18 by some 30 per mille relative to sea water, one might conclude that the abundance of oxygen-18 in the solutions from rock pores from which the calcite crystals in the clefts were crystallized was some 10 per mille higher than that in sea water; always provided, however, that the temperature was 200° C. or more, conditions under which the fractionation of the oxygen isotopes becomes negligibly small. Similar conditions may be assumed to have prevailed in the formation of the 'intrusive' carbonatites which, according to the graph, are only slightly richer in heavy isotopes on the average than the calcite crystals from Alpine clefts. There is, in fact, strong evidence that the abundance of oxygen-18 in the water of rock pores increases with depth[5] and that magmatic water is some 10 per mille richer in oxygen-18 than sea water[6]. Though it is not possible as yet to account for the relatively large variations in the isotopic composition of the 'intrusive' carbonatites, it should be mentioned that these samples have a very similar oxygen-18 abundance to that of magmatic oxygen. It is reasonable to suppose that the corresponding ratio carbon-13 to carbon-12 is therefore significant for magmatic carbon.

The metamorphic limestones show a widespread variety in their isotopic compositions, ranging from those of the sedimentary limestones to those of the 'intrusive' carbonatites. No apparent relationships have yet been found between the isotopic composition



Relative abundances of oxygen and carbon isotopes in carbonate rocks.

▲, Sedimentary limestones; ●, metamorphic limestones (mainly from the Swiss Alps); ■, intrusive carbonatites (from Alnö, Uganda, South Africa, Colorado); □, calcite crystals from Alpine clefts (all from the Simplon Tunnel); ○, calcareous sinters. Encircled points average isotopic composition of the different groups

of the metamorphic carbonate rocks on one hand, and their physical and chemical properties or their age or geographical location on the other. It is most probable that the isotopic differentiation was caused by the different amounts of water and carbon dioxide passing through the carbonates at high temperatures during their metamorphic recrystallization. Limestones recrystallized with very small amounts of water had no opportunity of changing their original (sedimentary) isotopic composition, whereas carbonate rocks supplied with large quantities of ascending water and carbon dioxide finally attained the isotopic composition of the 'intrusive' carbonatites. In fact, such compositions were found only in crystalline limestones from contact zones with igneous or ultrametamorphic rocks where vast quantities of water and carbon dioxide were available. According to preliminary investigations, the abundance of the heavy isotopes generally decreases with increasing distance from the contact zones, and metamorphic carbonates having the isotopic composition of sedimentary limestones have been found mainly in the central regions of large limestone bodies. The distances over which a considerable change in isotopic composition may occur range from a few centimetres to several metres.

The results so far obtained suggest that the study of isotopic differentiation in metamorphic carbonate rocks might yield valuable information on the distribution and migration paths of the water and carbon dioxide during metamorphism.

Further investigations on the local distribution of the oxygen and carbon isotopes in well-known metamorphic areas are in progress and the results will be published elsewhere together with the details of this study.

I am indebted to Prof. A. Holmes (Edinburgh), Dr. E. Wenk and Dr. O. Grütter (Basel), for many helpful discussions and for furnishing the rock samples.

P. Baertschi

Physikalisch-Chemisches Institut,
Universität, Basel.
May 25.

[1] Niggli, P., "Die Mineralien der Schweizeralpen" (B. Wepf and Co., Basel, 1940).
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Preparation of Uniform Solid Samples for Radioactive Assay

The preparation of uniform solid samples of radionuclides is of paramount importance in radiochemical assay, using end-window Geiger–Müller counters, especially for radionuclides emitting low-energy beta-radiation. For comparative measurements (using identically mounted samples), it is essential that all the deposits should be uniform and of the same dimensions, so that the factors due to absorption and scattering in the sample are constant.

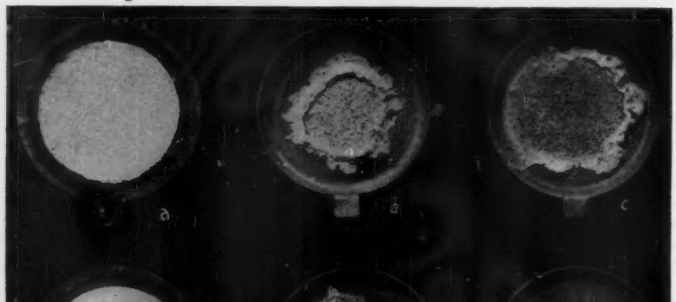
Many different methods for obtaining uniform deposits have been described[1] and these fall into two main categories: (1) those prepared by the evaporation of solutions; (2) those in which the deposition of a slurry of insoluble material is used.

The present method deals with the first case, that is, when the radionuclide compound is soluble. For routine work, a method often used is that of pipetting a small amount of the solution into a shallow metal dish and evaporating to dryness. Various devices have been used to induce uniform spreading and drying of the solution, as, for example, the addition of detergent or lens tissue or filter paper to the solution in the dish. It was found that methods involving the addition of a small amount of detergent did not give uniform deposits, and in some cases it caused the solution to creep over the edges of the dish. The present method, as well as giving a uniform deposit, accurately delineates the area of the active source, but requires no material to be added which would increase the absorption.

Circular stampings one inch in diameter with a protruding lug are made from 16-gauge aluminium sheet—the lug being used for ease of handling. The disk is held in a jig and the surface is 'turned-off' in the lathe from the centre outwards to a diameter of $\frac{5}{8}$ in. to a depth of about 5×10^{-3} in., and a clean square-cut edge is left, care being taken not to touch the unturned part around the edge of the disk with the cutting tool. A known volume of the radionuclide solution is pipetted on to the centre of a disk and then rapidly evaporated beneath an infra-red heater in a current of hot air. The air stream is directed at the surface of the disk from all sides, through a series of holes drilled in a 5-in. diameter tubular brass ring. If the disk is placed at the centre of the ring, the air flow may be adjusted so that the liquid rotates. Thus, the solution is stirred until drying occurs, and the effects which usually cause uneven deposition are largely neutralized. When dry, the disks are fitted into a recessed metal plate which is then placed beneath the window of an end-window Geiger–Müller counter. (As the disks are flat, the active sample may be placed closer to the window than is possible with the usual type of shallow dish.)

The method has been tested using sodium bromide solutions containing either sodium-24 or bromine-82. When the deposit is of sufficient density to be observed, it appears as a matt finish of fine crystals uniformly distributed over the whole of the 'turned' surface. The present method is suitable for moderately heavy deposits; for example, it is found that the evaporated salt is confined to the 'turned' area even when 0·5 ml. of 1·0 *M* sodium bromide is used, whereas previously half this quantity evaporated in a shallow aluminium dish of similar size gave extremely non-uniform deposits. The best results are achieved when the disks are freshly turned.

A total of 10,000 counts was taken for each deposit and the results were corrected for decay; but corrections for resolving time were not made, as all the counting rates were of similar magnitude. Sources prepared with nominally equal volumes (checked by weight) from one active solution were used and all mounted in exactly the same manner, so that the geometry and the scattering effects of the mount and surroundings were constant. The effect of instrumental errors in counting was tested by counting one deposit ten times. The variation in counts was not significantly greater than that expected in a Poisson distribution; hence, instrumental errors could be considered to be negligible. The uniformity of deposition was tested by preparing ten disks of 0·2 ml. of 0·01 *M* sodium bromide containing sodium-24. The variation in counts was again not significantly greater than that expected in a Poisson



distribution; that is, there was no experimental evidence of difference between the disks.

In the course of some other work, a large number of sodium bromide deposits containing either sodium-24 or bromine-82 have been tested using this method, taking three 0·2-ml. samples from each solution (from solutions of varying concentration up to 1·0 molar), and each set of three samples also gave results within the Poisson distribution.

Figs. *a* and *d* indicate clearly the uniform deposit obtained by this method, as compared with those obtained (*b*,*c*) by evaporating the solution in a dish, or those (*e*,*f*) when detergent is added to the solutions in the dish. In each case 0·2 ml. of sodium bromide has been used. Figs. *a*, *b* and *c* are for 1·0 *M* and Figs. *d*, *e* and *f* for 0·1 *M* solutions.

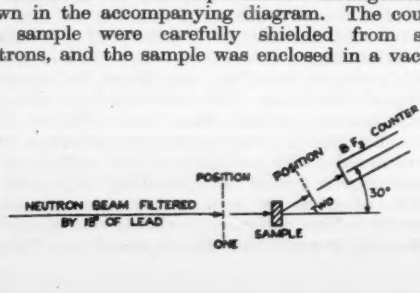
My thanks are due to Dr. A. Robson for discussion.

M. L. Wright
Wool Industries Research Association,
Torridon,
Headingley, Leeds 6.
April 27.

[1] For example, Kohman, T. P., *Anal. Chem.*, **21**, 352 (1949).

Inelastic Scattering of Cold Neutrons

The gain of energy of cold neutrons on being scattered by crystalline materials has been investigated with a beam of lead-filtered neutrons from the Harwell pile. The maximum energy of the neutrons in the beam was 0·0026 eV. and the mean energy was 0·0017 eV. The experimental arrangement is shown in the accompanying diagram. The counter and sample were carefully shielded from stray neutrons, and the sample was enclosed in a vacuum chamber to eliminate air scattering. The angle of scattering was 30 ± 5°. The transmission of a lithium fluoride plate (0·14 gm./cm.²) was measured in positions 1 and 2 for different scattering samples. The transmission of the plate had been measured as a function of energy with a mechanical spectrometer, so that a mean energy of the beam could be determined from these measurements. From the measurement in position 1 the mean energy of the neutrons which are scattered into the counter is determined *before* they are scattered, and from the measurement in position 2 the mean energy is determined after scattering. The results are shown in the accompanying table.



The cross-section (assuming the scattering to be isotropic) was determined by calculating the ratio of scattering to total cross-section of the sample, from the ratio of the counting rates obtained with the sample and the thin hydrogenous sample.

Element	Thickness in mean free paths	1 Initial energy*	2 Final energy*	Cross-section if isotropic	Cross-section determined from transmission data
H	0·81	1·75±0·10	1·75±0·10	—	—
H	1·4	1·60±0·10	2·85±0·25	—	—
H	3·4	1·75±0·10	9·3 ±1·8	—	—
Be	0·60	1·3 ±0·3	5·0 ±1·7	?	—
V	0·92	1·7 ±0·2	1·5 ±0·2	6±1	4·7
Se	1·06	—	—	2·5±1	4±2
Mo	1·00	—	—	<0·3	<0·3
Fe	0·98	1·65±0·25	9·8 ±1·8	1·5±0·5	1·4

* The energy is expressed in units of 10^{-3} eV.

In the case of hydrogenous media, the presence of inelastic scattering is only observable with the thicker samples. In crystalline materials, the scattering cross-section at neutron wave-lengths greater than the Bragg limit is made up of inelastic scattering due to thermal vibrations and elastic incoherent scattering due to spin and isotope effects. The result with beryllium confirms that the inelastic cross-section is much greater than the incoherent cross-section, although the value for the final energy is too low because the inelastically scattered neutrons are appreciably Bragg-scattered. The vanadium measurements verify that the scattering is largely incoherent. The measurements with selenium and molybdenum were made to confirm the order of magnitude of the inelastic and incoherent cross-sections which had been determined from the total cross-section.

The scattering cross-section of iron[1] is known to be greater than the thermal inelastic cross-section at long wave-lengths, and the present measurements verify directly that the difference is due to inelastic scattering. It is believed that this is magneto-thermal scattering[2].

P. A. Egelstaff
Atomic Energy Research Establishment,
Harwell, Nr. Didcot, Berks.
April 16.

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A New Method of Observing Compton and Other Incoherent X-Ray Scattering in Crystals

If a narrow cylindrical beam of copper K + white radiation is allowed to impinge on an iron foil of suitable thickness, placed in contact with a mosaic-type diamond (the foil being between the X-ray source and the diamond), an excellent divergent-beam pattern due to fluorescent iron K radiation can be obtained, superimposed on the Laue pattern of the diamond[1,2].

Even when the foil is removed, however, a weak divergent-beam pattern is still observed on sufficiently well-exposed Laue photographs, but it now corresponds to that expected for copper K wide-angle radiation. It was at first thought that this indicated the presence of copper as an impurity in the crystal, in sufficient quantity for a high proportion of fluorescent copper K radiation to be generated. This initial hypothesis was disproved by the following considerations and experiments.

(*a*) The effect is found for clear, colourless diamonds which would not be expected to contain copper as an impurity.

(*b*) Copper is a more unusual impurity than iron even in the opaque, coloured Belgian Congo diamonds which showed the copper K spontaneous pattern most clearly; yet, with an incident pencil of copper K radiation, for which the iron K fluorescence might be expected to be far more intense than any copper K fluorescence, no iron K spontaneous pattern was found.

(*c*) To check this reasoning, a spectrographic analysis of two Belgian Congo diamonds showing the effect was kindly undertaken by Miss Czapska, of Hilger and Watts, Ltd. This showed the presence of iron and silicon, but not of copper.

(*d*) A Laue photograph taken with cobalt K + white radiation showed a weak superimposed divergent-beam pattern due to cobalt K wide-angle radiation only.

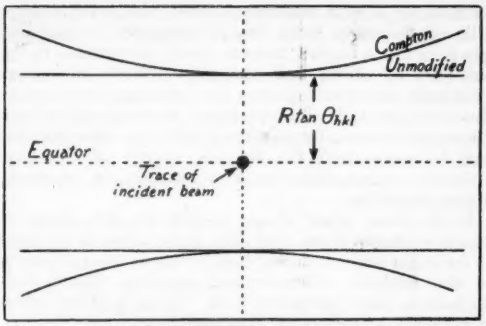
(*e*) Similar spontaneous wide-angle patterns were found for a mosaic benzophenone crystal using copper K and cobalt K incident beams respectively; and for a graphite crystal, using copper K radiation, when the incident beam was parallel to the basal plane.

Since the source of wide-angle radiation is within the crystal, and is not fluorescent radiation but of a kind similar to that in the incident beam, it must be either Compton scattering or imperfection scattering (including thermal scattering) or both.

This is confirmed by the observation that in the neighbourhood of the undeviated incident beam only reflexion conics, and no absorption conics, are recorded; which means, in effect, that the wide-angle source of radiation within the crystal has zero or low intensity near the incident beam direction, as would be expected for all such secondary radiation, but not for fluorescent radiation, or for low-angle scattering of any kind.

Owing to the difficulty of obtaining a pattern sufficiently intense for precise measurements of high-angle conics, it has not so far proved possible to distinguish between the effects due to the two types of incoherent scattering.

In principle, however, this could be done. In Compton scattering the wave-length of the scattered radiation is altered by up to 6 per cent, according to the incident radiation and the angle of scattering,



Appearance of the hkl conic on a cylindrical film of radius R, when the planes (hkl) are perpendicular to the axis of the film. The curvature of the Compton conic is greatly exaggerated

whereas for imperfection scattering the wave-length change is only about 10^{-3} per cent. If the crystal is set with a plane (hkl) accurately perpendicular to the axis of a cylindrical camera, the divergent beam conics due to this plane will appear symmetrically on each side of the equator. If the pattern is due to the comparatively unmodified radiation, the conics will be a pair of lines parallel to the equator of the film; if it is due to Compton scattering the lines will diverge (appreciably for high-angle conics) as the angle of deviation from the incident beam increases (see diagram). Deviations from parallelism due to unwanted curvature of the film, etc., could be corrected for automatically by superimposing on the pattern a rotation photograph taken in the same orientation. In certain circumstances the mth-order conic will coincide with the nth rotation layer line, and any high-angle deviation could be observed. (For example, the deviation would be of the order of 2 mm. in the separation of the 220 copper $K\alpha$ conics for an angle of scattering of 140° for diamond with [110] parallel to the camera axis, using a cylindrical film of diameter 6·0 cm.).

The method is one which, if difficulties of technique are overcome, may be expected to give information about the relative amounts of Compton and imperfection scattering in various directions.

I wish to express my thanks to Prof. Kathleen Lonsdale for interest and advice during the course of this work.

H. J. Grenville-Wells

University College,
London, W.C.1.
May 12.

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Intensity Variation in Sunspots

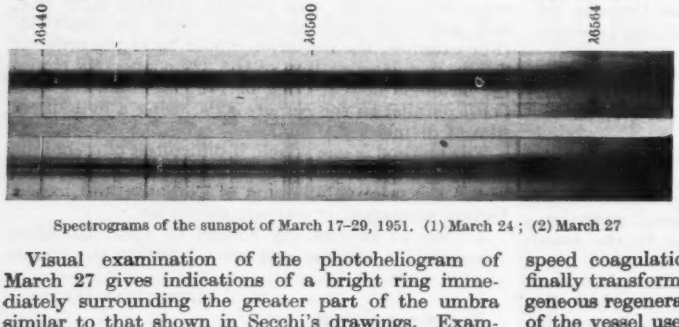
The most conspicuous and readily observed feature of a normal sunspot is a dark central umbra surrounded by a less dark penumbral fringe which, under good seeing conditions, appears to be composed of converging filaments directed radially inwards. Secchi[1] concluded from his visual observations that the penumbra is brighter at its inner edge, that is, towards the periphery of the umbra and darker at its outer edge. This feature is clearly shown in his drawings of sunspots.

Measurements of the variation of total energy across a sunspot with a thermocouple led Pettit and

Nicholson[2] to the conclusion that the total energy falls *continuously* from the photosphere throughout the penumbra to the umbra, where it remains fairly constant at about half the photospheric intensity. Wormell[3], who made similar measurements, arrived at the same result. He has remarked, however, that when allowance is made for scattered light, the observations can be accounted for by an umbra of constant intensity surrounded by a penumbra of constant higher intensity.

It is clear that these results do not support Secchi's observation that the penumbra is darkest at its outer edge and brightest towards the periphery of the umbra. Commenting on this, Pettit and Nicholson have remarked that "Secchi's observation is possibly an effect of contrast".

Recently, while taking spectrograms of the large sunspot of March 17–29, 1951, in the course of a study of the spectral intensity variation in sunspots, it was found that the umbral spectrum was bordered on either side by bright margins separating it from the penumbral spectra. The first observation of this was made on spectrograms taken in the *H*-alpha region of the first order of a 20-ft. grating spectrograph at 0430 hr. U.T. on March 24 (Fig. 1). The heliographic co-ordinates of the spot at that time were approximately latitude 12° N., longitude 15° W. The phenomenon was observed in a more striking manner on spectrograms taken at 0345 hr. U.T. on March 27 (Fig. 2). The heliographic co-ordinates of the spot at this time were latitude 12° N., longitude 55° W. Between March 24 and 27, the umbra of the spot had bifurcated and the bright bridge across the two halves of the umbra is clearly visible on the spectrogram of March 27.



Spectrograms of the sunspot of March 17–29, 1951. (1) March 24; (2) March 27

Visual examination of the photoheliogram of March 27 gives indications of a bright ring immediately surrounding the greater part of the umbra similar to that shown in Secchi's drawings. Examination of a number of old photoheliograms indicates that in the case of several spots the inner edge of the penumbra is brighter than its outer edge. A detailed microphotometric study of past photoheliograms taken at this Observatory is in hand.

Although several spot spectra have been taken on previous occasions, the phenomenon reproduced in the accompanying spectrograms has not been observed. The majority of the spectra do not show the sharp demarcation of intensity between the umbra, the penumbra and the photosphere which is so clearly visible on photoheliograms taken under good sky and seeing conditions, but show a continuous rise of intensity from the centre of the umbra through the penumbra towards the photosphere. This is presumably due to the wandering, owing to atmospheric unsteadiness, of the image on the slit of the spectrograph during the exposure. The two necessary conditions for accurate estimation of the intensity variation in sunspots are good sky and seeing and short exposure. A solar image of 60 mm. diameter formed by a 21-ft. photo-visual lens was employed in the present case and the exposures varied from 1 to 3 sec.

R. Ananthakrishnan

Solar Physics Observatory,
Kodaikanal.
April 25.

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Effects of Ultrasonic Irradiation on the Coagulation of Cellulosic Solutions (Viscose)

The rate of coagulation of high polymeric colloidal solutions can be examined by a method devised by us, similar to that used for the study of the coagulation of recalcified blood plasma.

If the rates of coagulation and regeneration of a cellulosic gel are diminished by suitable means[1], it is possible to follow these phenomena spectrophotometrically. In this way a coagulation speed curve can be determined. The shape of this curve shows whether impurities are present or not, and also makes possible a study of the effect on coagulation of various chemical and physical agents (electromagnetic waves, ultra-violet radiations, etc.). We report here our first results concerning the effects of ultrasonic irradiation on the coagulation of cellulosic solutions and on the quality of the cellulosic lump obtained after regeneration.

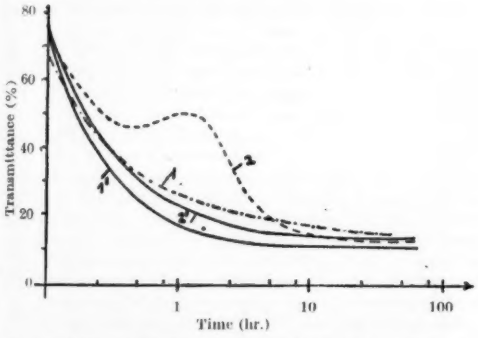
Our method of slowing down the coagulation and regeneration rate consists in mixing drop by drop—contrary to industrial procedure—the diluted spinning-bath solution with the weakly diluted viscose (about 1 : 4) or cellulosic solution, and stirring the mixture continuously in a regular manner. The process is stopped as soon as the coagulating reaction starts. In this way it is possible to initiate a low-speed coagulation and regeneration reaction which finally transforms the mixture into an optically homogeneous regenerated cellulosic lump, taking the shape of the vessel used. After achievement of this phase, which lasts several hours, the lump begins to shrink and is transformed into a stiff and hard piece of cellulose; this transformation may last several days.

Three different types of ultrasonic apparatus were used. The first was an ultravibrator, frequency 800 kc./s., 50-watt total acoustic energy (maximum) and 4·6 watt/cm.^{2} maximal concentration, the second a Therasonel 015 (*ACEC*) with a frequency of 1,000 kc./s., 15-watt total acoustic energy, 1·8 watt/cm.^{2} maximal concentration, and the third a specially built experimental unit giving 50 watts total acoustic energy at a frequency of 3,200 kc./s. and an acoustic concentration of 5·5 watt/cm.^{2}.

The samples to be irradiated were placed in vessels of which the diameter was the same as the transmitting head. A cooling system using running cold water holds the sample at a constant temperature in spite of the heating effect of the ultrasonic radiation. Nevertheless, it was not possible to avoid specific thermal effects occurring in discrete points of an

inhomogeneous medium which absorbs more or less energy than the surrounding liquid; microscopical temperature gradients are produced as during the treatment of inhomogeneous material with electromagnetic short-wave radiation[2]. Measurement of the ultrasonic dose (watt/cm.^{2}) is carried out by a differential thermocouple and that of the integral dose (watt. time) by insertion of small vials filled with an acidified solution of potassium iodide and starch[3]. Iodine is liberated by the action of ultrasonic radiation, and the depth of the blue colour—measured photometrically—gives the integral dose applied. In this manner the transmitted dose could be kept constant while using three different frequencies.

We have irradiated (*a*) the viscose before mixing with the coagulating solution and (*b*) the viscose after mixture with the coagulating solution. The three principal effects were: (1) outgassing by expulsion of included minute bubbles; (2) acceleration of the rate of coagulation and regeneration; (3) acceleration of dissolving and diffusing action of the spinning solution within the viscose.



Characteristic coagulation-speed behaviour of two different commercial viscoses (1 and 2). Curves 1′ and 2′ refer to the respective irradiated samples; their initial inclination (initial speed) is 2–3 times greater; however, the final transmittance is nearly the same in irradiated and non-irradiated samples. The abnormal behaviour (saddle form) of coagulation in sample 2 is not shown by the irradiated sample 2′

The cavitation effect occurring was positive and the speed of expelling hydrogen sulphide during the progress of regeneration was increased. The accompanying figure shows different photometric curves obtained under the influence of ultrasonic irradiation.

We have not found any remarkable differences due to change of frequency. Visible cavitation took place at about 0·65 watt/cm.^{2}. At that dose we had to irradiate for at least 15 min. to obtain a noticeable effect of acceleration on the rate of coagulation. The higher the dose the smaller was the time necessary to obtain an effect; however, there is not a linear relation between these factors. Macroscopic thermal effects do not seem to interfere with the process, because controls kept at 28° C., that is, 7° C. higher than the irradiated-samples, showed no effect.

The acceleration of the dissolving and diffusing action of the spinning solution into the viscose and the outgassing of the mixture were clearly shown by the increase of light transmission through the sample at the beginning of coagulation when there is a nearly linear relation with the applied dose. The initial value of transmittance depends on the kind of viscose and coagulating solution, as well as on the quantities used.

As regards the structure of the regenerated lump of cellulose, we cannot be sure that the yield of the crystalline form and orientation are changed. However, the mechanical consistency of the lump is a little greater. Further work on this point is being carried out. The modification in the rate of the coagulation was only seen clearly when mixtures of viscose and spinning solution were irradiated.

I wish to thank the Director of Fabelta S.A., Brussels, for allowing me to publish parts of this work which were done in that laboratory.

V. Tomberg

Laboratoire de Physique,
Institut de Pharmacodynamie,
Université Libre de Bruxelles,
115 Bvd. de Waterloo,
Bruxelles.
March 30.

[1] Tomberg, V., Acta III Congr. Nat. Sci., Brussels (1950).
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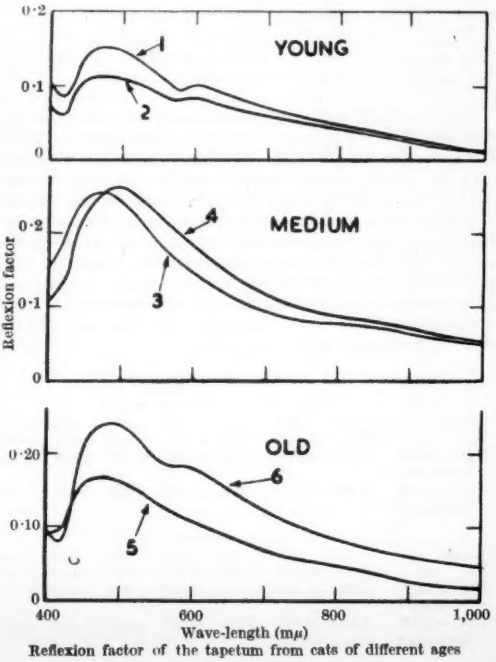
Spectral Reflexion Factor of the Cat's Tapetum

The physiological function of the tapetum in the eyes of animals of nocturnal habit is uncertain. However, it may fairly be assumed that by reflecting light incident on the retina back through the layer of end-organs, the tapetum reduces in some measure the absolute threshold for vision[1]. Since the tapetum is coloured, spectral sensitivities determined from absolute thresholds will also be modified. Murr[2], working on the light sense of the domestic cat, attributed differences in the wave-length of maximum visual sensitivity to differences in tapetum colour. In particular, he suggested that there occur changes of this kind during the life of the animal.



Reflexion factor of the tapetum from cats of different ages

To see whether tapetum reflexion was likely to be a factor in the current work of one of us (R. G.) on the cat's spectral luminosity curve, the spectral reflexion curves shown in the accompanying graphs were obtained. The tapeta of six freshly killed animals of different ages were dissected out, mounted in glycerine on 'black' glass, and measured on the G.E.C. recording spectrophotometer. Because of the rather small area of the tapetum—about 1·4 sq. cm. —it was necessary to use auxiliary lenses placed in the beam of the spectrophotometer in order to concentrate the light on the specimen. It was also necessary to apply a correction for light reflected not by the actual tapetum but by the surrounding black cardboard mask which exposed only the selected area of the specimen. The radiation specularly reflected at the glass–air surface of the cover glass falls on an absorbing surface in the instrument and is not included in the measured reflexion factor.

The corrected values given in the graphs show a main maximum reflexion factor at about 480 mμ and, in some cases, a rise as 400 mμ is approached and a rudimentary maximum at about 600 mμ. These last two features seem to occur together. It was obvious by direct inspection that the specimens were not uniform in colour. Probably at least two different pigments are playing a part. From the summary of the main features of the curves (Table 1), it appears that for the young cats the reflexion from the tapetum was weaker, and rather more to the blue than for the others, but the differences in this latter respect are not marked.

Table 1

Specimen No. and age of cat	Main maximum		Indications of secondary maxima	
	Wavelength	Reflexion at maximum	Below 400	Near 600
1 young	470	0·150	present	present
2 young	465	0·110	,,	,,
3 medium	470	0·254	absent	absent
4 medium	500	0·260	,,	,,
5 old	480	0·166	slight	,,
6 old	490	0·238	present	present

If the relative spectral sensitivity of the animal's eye would be V_λ if the tapetum were absent, some idea of the modification produced by the tapetum can be obtained by increasing V_λ by the factor $K(1 + \rho_\lambda)$. Here ρ_λ is the reflexion factor of the tapetum at λ and K is a constant introduced to restore the maximum sensitivity to the value unity. As an illustration, the changes in the photopic and scotopic spectral sensitivity curves of the human eye if a tapetum similar to specimen 1 or specimen 4 were introduced have been calculated in this way (Table 2). The changes are very slight.

Table 2

Photopic curve

λ (mμ)	460	480	500	520	540	560	580	600	620	640
V_λ	0·060	0·139	0·323	0·710	0·954	0·995	0·870	0·631	0·381	0·175
$V_\lambda(1+\rho_\lambda)K$ Tapetum 1	0·062	0·144	0·333	0·726	0·964	0·993	0·859	0·625	0·377	0·171
$V_\lambda(1+\rho_\lambda)K$ Tapetum 4	0·061	0·143	0·333	0·726	0·964	0·991	0·853	0·611	0·364	0·165

Scotopic curve

λ (mμ)	420	440	460	480	500	520	540	560	580	600
V_λ	0·097	0·313	0·570	0·796	0·962	0·933	0·597	0·318	0·124	0·036
$V_\lambda(1+\rho_\lambda)K$ Tapetum 1	0·093	0·309	0·577	0·807	0·970	0·933	0·589	0·310	0·120	0·035
$V_\lambda(1+\rho_\lambda)K$ Tapetum 4	0·088	0·301	0·564	0·798	0·968	0·933	0·589	0·309	0·119	0·034

It seems unlikely that the presence of a coloured tapetum can be modifying materially the observed spectral sensitivity curve of the cat's eye.

R. Gunter
Medical Research Council
Vision Research Unit,
H. G. W. Harding
W. S. Stiles
Light Division,
National Physical Laboratory,
Teddington.
April 5.

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Estimation of Volatile Fatty Acids and Ammonia in Silage by means of Paper Chromatography

Silage-making is becoming more and more general in many countries, and it is necessary to pay more attention to its quality because the quality of milk and milk products suffers from a bad silage. The quality control of silage is therefore important. The simplest and quickest method of control is the determination of *p*H. In general, it can be said that when the *p*H of silage is between 3 and 4 (the AIV method) the decomposition processes (formation of carbon dioxide, ammonia and volatile acids) are slight in the silage and its quality is good. When the *p*H rises, the quality of the silage is lowered. Formation of butyric acid is then common, and ammonia is formed freely. Determination of these substances is of first importance in the control laboratories.

We have applied the chromatographic determination method of fatty acids developed by Hiscox and Berridge[1] to silage analysis, and have found that the analysis of butyric acid can be made directly from the effluent, which contains inorganic and organic ions. The spots have then frequently a slightly intenser colour than those produced by the corresponding amount of pure butyric acid in aqueous solution: this must be considered at estimation. Acetic acid cannot be determined in this way mainly owing to lactic acid, which proceeds almost at the same rate. If it is desired to determine acetic acid along with butyric acid, the acids must be distilled off from the effluent and the chromatographic determination made from the distillate.

The results of our determinations are illustrated by Fig. 1 and the accompanying table. Determination of butyric acid by paper chromatography is accurate enough for practical silage control.

Fig. 1 shows that silages of low quality may contain, in addition to butyric acid, also valeric acid (samples 2 and 4) and even caproic acid (sample 2). Propionic acid, too, often occurs.

Ammonia can be roughly determined by paper chromatography, also directly from the effluent (Fig. 2). Butanol–hydrochloric acid (2 vol. of *n*-butanol + 1 vol. of 6 *N* HCl) is used for the solvent, and the ammonia spot is developed by drawing the strip rapidly through

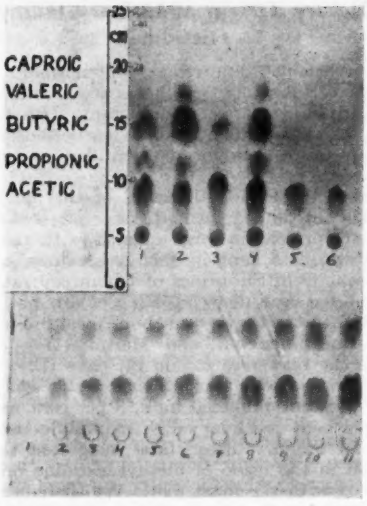

Fig. 1. Paper chromatograms from six silage samples (raw effluents), with the following *p*H values (Nos. 1–6): 4·2, 4·3, 4·0, 5·0, 3·8 (AIV), 3·9 (AIV) (upper paper) and from a control series containing butyric acid 0·1, 0·2, . . . 1·1 per cent and acetic acid respectively 0·2, 0·4, . . . 2·2 per cent (lower paper). Solvent: *n*-butanol saturated with water + ethylamine; paper: Whatman No. 1. Solvent frontier advanced in 18 hr. 28 cm. Acetic acid advanced from the initial point 4–5 cm., butyric acid 10 cm.

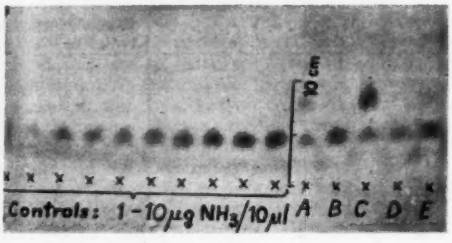

Fig. 2. Paper chromatogram from five silage samples (*A*–*E*) and from a control series with known amounts of ammonium sulphate

Nessler's reagent[2] and washing it in water. In some silages a faster moving greenish spot is produced by Nessler's reagent, in addition to an orange ammonia spot. This substance has not yet been identified.

The optimum concentration region for ammonia in the paper chromatography is within 1 and 10 μgm., which means 0·1–1·0 mgm. NH_3/ml. when 10 μl. drops are used. The ammonia content of the effluents of good-quality silages is just within this region. Low-quality silages may contain considerably more ammonia and must be suitably diluted before the drop is placed on the paper. Since the salts contained in the effluent cause spreading of the spots, we have used about 1 per cent di-potassium phosphate in the reference solutions.

As the ammonia spot rapidly fades, the comparison of the spots must be made quickly, preferably when the paper is still in the wash-basin. Determination of ammonia by means of paper chromatography is not accurate (cf. the table); but it gives a rough idea of the ammonia content of silages. Distillation of an effluent made slightly alkaline to about half of its volume and titration of ammonia from the distillate gives, of course, a more exact result; but the paper chromatography may be useful in control laboratories as a work-saving method.

A detailed account will be published in *Ann. Acad. Sci. Fennicæ*.

Artturi I. Virtanen
Jorma K. Miettinen

Biochemical Institute,
Helsinki.
March 17.

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A Phosphate Ester of a Tricarboxylic Acid in Liver

We have found that the compound isolated from dog's liver and previously considered to be a phosphotrihydroxyglutaric acid[1] is instead the phosphate ester of a tricarboxylic acid. The data indicate that the compound is 2-phospho-4-hydroxy-4-carboxyadipic acid. Since work had to be interrupted for external reasons, a preliminary report is being made at this time.

The most important evidence was derived from oxidative degradation of the phosphate-free compound, which was obtained from the parent substance by prolonged acid hydrolysis or, in a more satisfactory manner, by action of alkaline phosphatase. Oxidation with permanganate or dichromate at 100° C. in the presence of mercuric sulphate and sulphuric acid (Denigés reagent) yielded the char-

Analyses of Effluents from Five AIV-Silage Samples

*p*H		*A* 2·6*	*B* 4·3†	*C* 3·4	*D* 4·0	*E* 3·5
Volatile fatty acids: By paper chromatography (directly from effluent)	Propionic acid, per cent Butyric acid, per cent	0·0 0·0	0·1 0·7	0·0 0·0	traces 0·0	0·0 0·0
By quantitative distillation (Virtanen and Pulkki[3])	Acetic acid, per cent Butyric acid, per cent‡	0·44 0·00	1·10 0·81	0·39 0·04	0·81 0·00	0·32 0·00
Ammonia: By paper chromatography μgm./10 μl. (=mgm./10 ml.)		2, 3, 3 } 2·7	10, 7, 9 } 8·7	4, 3, 5 } 4·0	3, 4, 4 } 3·7	5, 4, 6 } 5·0
By distillation (Pucher *et al.*[4]), mgm./10 ml.		2·04	9·64	2·50	4·56	3·39

* *p*H too low.
† *p*H too high.
‡ Distillation method gives somewhat too high values for butyric acid if the silage contains propionic acid and/or acids higher than butyric acid. Paper chromatogram makes possible identification of the acid.

acteristic precipitate of the mercury complex of acetone, which was further identified by distillation from the complex and by several characteristic reactions. Acid permanganate – bromine oxidation at 7° C. yielded 3·94 moles of carbon dioxide and pentabromacetone, which was identified by melting point, mixed melting point with an authentic preparation, and colour tests. The formation of pentabromacetone in nearly quantitative yield may be considered as a specific test for acetonedicarboxylic acid or for substances yielding it on oxidation[2-4]. Unlike compounds of the structure $R,R'=C=(COOH)_2$, which readily evolve carbon dioxide when heated in the dry state, the phosphate-free compound lost no carbon dioxide when heated up to 160° C. *in vacuo*. A stable, but hygroscopic, monolactone was formed easily, and there was some evidence of a second, weak, lactone linkage on the basis of titration in ice-cold solution. Analyses gave the following results:

	$(C_7H_{12}O_8)$ calc.	found
Equivalent weight of the phosphorus-free compound	74	71–78
" " " " " " lactone	68	68
Molecular weight " " " " "	204	201

Elementary analysis of the barium salt of the phosphorus-free compound gave:

$C_7H_7O_8Ba_{1\cdot5}$. Calculated, C, 19·8; H, 1·65; Ba, 48·5.
Found, C, 19·9; H, 1·54; Ba, 50·5.

With the phosphate ester, electrometric titrations gave 4·5–5·0 equivalents of hydrogen ion per mole of phosphate, and the equivalent weight was 66–69 (calculated for $C_7H_{11}O_{11}P$, 60·4). On oxidation with dilute permanganate solution, 2 moles of carbon dioxide were formed without hydrolysing the ester linkage. The oxidation product contained a carbonyl group, indicating the presence of a second hydroxyl group, other than that esterified with phosphate. It would appear that the carbonyl arose from the tertiary hydroxyl group by oxidative decarboxylation.

The following properties of the compound are of interest: (1) the phosphorus-free compound gives a dusty pinkish-red colour when heated with a mixture of pyridine and acetic anhydride (Fürth–Herrmann test[5]), similar to that of citric acid; (2) the phosphate ester shows only weak optical activity $[M]^{20°}_{5461} = -3·0°$ (c, 0·26 M); (3) the phosphorus-free compound, when mixed with ammonium molybdate, was highly active $[M]^{20°}_{5461} = +230°$ (c, 0·003 M), a property shown by many hydroxypolycarboxylic acids; (4) acid periodate oxidation of the phosphorus-free compound for 10–60 min. gave 0·7 mole uptake of oxygen; (5) with hypoiodite, about six equivalents of iodine are consumed and iodoform is formed.

The possible biological role of the compound, which may be thought to arise from the condensation of phosphopyruvic and malic acids, appears of great interest.

We are indebted to Dr. G. Schmidt, Tufts Medical School, Boston, Mass., for a generous supply of intestinal alkaline phosphatase.

S. Rapoport
Robert H. Wagner
Children's Hospital Research Foundation,
Cincinnati, Ohio.
April 12.

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Dietary Origin of Urinary Methyl-Histidine

The variable occurrence in normal human urine of a substance giving a green colour with ninhydrin on paper chromatograms (R_F 0·86 in phenol, 0·28 in collidine–lutidine) has been described[1]. This substance has been identified as methyl-histidine[2].

Previous to the identification of this amino-acid as methyl-histidine, we had observed that it was constantly present in large quantities in the urines of domestic cats kept in this Laboratory, while it was absent from the urines of laboratory rats. The cats were fed on a diet consisting of raw beef 73 per cent, boiled liver 24 per cent, bone meal 0·5 per cent, cod liver oil 2 per cent, and 'Marmite' 0·5 per cent, whereas the rats were fed on rat cake (Diet No. 41 of the Associated Flour Millers, Ltd.) which contains 3 per cent skimmed milk, 8 per cent fish meal and 2 per cent cod liver oil as the only constituents of animal origin. These facts suggested that the excretion in the urine of methyl-histidine might be associated with the meat diet. We therefore examined the urines of a number of species of carnivores, rodents and herbivores, with the results shown in Table 1. These observations are consistent with the hypothesis that the urinary excretion of methyl histidine is correlated with a meat diet.

Table 1

Species	Diet	Urinary methyl histidine
Domestic cat	Meat	++++
Lion	"	+++
Tiger	"	+++
Ocelot	"	+++
Puma	"	++
Kenya genet	"	++
Dog	"	+++
Rat	Mixed	–
Mouse	"	–
Golden hamster	"	–
Rabbit	Vegetarian	–
Guinea pig	"	–
Horse	"	–
Cow	"	–

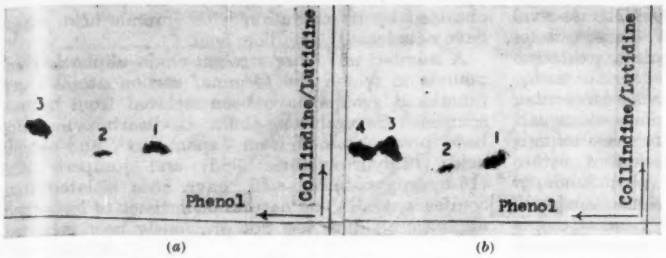
Our thanks are due to Dr. D. M. Walker for information about cows, and Mr. A. G. Searle about mice.

It might be reasonable to expect that the urinary methyl-histidine was derived from ingested anserine (beta-alanyl-methyl-histidine), which, as is well known, occurs in variable amounts in most vertebrate muscle. It should be noted that the urinary excretion of methyl-histidine is not correlated with the amounts of anserine present in the muscle of the species studied, as both the rabbit and the cat are known to contain relatively large and approximately similar concentrations of anserine in their muscles[3].

In order to explore the factor of ingested anserine, two human subjects were fed approximately 250 gm. roast rabbit meat, and their urine examined before

Table 2

Time (hr.)	Before hydrolysis		After hydrolysis	
	Methyl-histidine + anserine	beta-Alanine	Methyl-histidine	beta-Alanine
0	–	–	–	–
3	+++	–	+++	+++
12	+++	–	+++	+
21	+++	–	+++	trace



Chromatograms of urine (subject 1): (*a*) before ingestion of 250 gm. rabbit muscle; (*b*) 3 hr. afterwards.
In each case 15 ml. of urine was applied to the paper in the right-hand corner. The individual spots were identified as: 1, glycine; 2, glutamine; 3, β-amino-*iso*butyric acid 4, anserine and methylhistidine

and at different times after the meal. Rabbit muscle contains between 200 and 500 mgm. anserine and 50–80 mgm. carnosine per 100 gm. wet weight[3]. As in our other experiments, the urine was run on 20 cm. squares of paper under conditions previously described[4]. Chromatograms were also prepared in each case from the urines after hydrolysis with 5 *N* hydrochloric acid at 100° C. for 24 hr. The results were substantially the same for both subjects and the results for one of them are shown in Table 2 (see also illustration).

We found that it was not possible to resolve anserine from methyl-histidine satisfactorily where one or other substance was present in relatively large concentrations. Consequently the increase in beta alanine after hydrolysis was taken as an index of the amount of anserine present in the urine. In no case was an increase in histidine noted after hydrolysis, which makes it reasonable to assume that most of the beta-alanine was derived from anserine and not from carnosine (beta-alanyl-histidine), which also moves to a position similar to anserine and methyl histidine on our chromatograms.

The results of this experiment support the view that a carnivorous diet can give rise to the urinary excretion of methyl-histidine. Furthermore, it indicates that the large variation of urinary concentrations of methyl-histidine encountered in human urines can be accounted for in part in terms of dietary variations. The findings also suggest that the peptide anserine may be absorbed intact from the gut and that during the first few hours after absorption it may be excreted unchanged in the urine.

After the heavy protein meal ingested in this experiment, there was relatively little increase in the urinary excretion of other amino-acids to be detected on the chromatograms compared with the anserine and methyl-histidine excretion. This suggests that the renal thresholds for these substances are relatively low. Some support for this view has also been obtained in the cat, where chromatograms of up to 500 micro litres of plasma (after ultra-filtration) have failed to reveal any appreciable quantity of methyl histidine, even though this substance was being excreted in relatively high concentrations in the urine.

These results raise the question of the site and mode of hydrolysis of anserine in the body. Enzymes which will hydrolyse anserine and carnosine have been described in liver, kidney, spleen, small intestine mucosa and intestinal juices of various animals. It is also interesting to note that Parshin found the carnosinase activity of the mucous membrane of the small intestine of man was lower than all but one of the animals examined[6]; his results also indicate that this enzyme is most active in carnivorous animals. Species differences of this sort may well play a part in our results in so far as they may explain the finding of methyl-histidine alone in the urine of carnivorous animals and a mixture of anserine and methyl-histidine in the urine of human subjects fed a high protein meal.

We are grateful to Dr. E. Hindle and the Zoological Society of London for specimens of urine from various animals.

S. P. Datta
H. Harris

Biochemistry Department
and Galton Laboratory,
University College,
London, W.C.1.

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Kidney Citrate Levels in Nucleotide Shock

During recent studies on carbohydrate metabolism in shock, we have examined the citrate-level in the kidney of the fasting rat by Buffa and Peters's modification[1] of the method of Pucher, Sherman and Vickery[2], during the shock state produced by the parenteral injection of nucleotides. A marked increase ($P = 0{\cdot}01$) in the citrate content of the kidney occurred 1 hr. after the intraperitoneal injection of a lethal dose of adenosinetriphosphate (250 mgm. magnesium adenosinetriphosphate per 100 gm. body-weight in the strain of rat used, at an environmental temperature of 18–22° C.; see table). This increase was not maintained, and 4 hr. after the injection the level had returned to normal. In its time relationships this effect resembles that seen in fluoroacetate poisoning; but in the latter condition the increase in the citrate content of the rat kidney is much greater[1,3].

The kidney was chosen for study because it shows the most striking changes in fluoroacetate poisoning[1]. However, this effect of adenosinetriphosphate was not

Effect of the intraperitoneal injection of 250 mgm. magnesium adenosinetriphosphate per 100 gm. body-weight on the citrate concentration in the kidney of normal and medullectomized (40 days post-operative) fasting rats compared with the level in control rats given an equivalent amount of D-ribose

	No. in group	Citrate concentration in kidney (μgm. per gm. wet weight) Mean	Standard deviation
Controls	16	36	16·5
Normal rats:			
1 hr. after adenosine-triphosphate	11	93	44·3
4 hr. after adenosine-triphosphate	6	54	31·8
Medullectomized rats:			
1 hr. after adenosine-triphosphate	6	32	6·2

confined to that organ, for an elevated citrate-level was also found in the diaphragm. These results suggest some interference with carbohydrate oxidation during the shock state.

Little can be said, at the present time, concerning the mechanism of the effect. The magnesium salt of adenosinetriphosphate was used in these experiments; but there was no accumulation of citrate after the injection of molecular equivalent amounts of magnesium chloride. Nucleotide shock is accompanied by the liberation of adrenaline[4,5], and attempts were made to reproduce the effectby the subcutaneous injection of adrenaline hydrochloride (0·1 mgm. per 100 gm. body-weight). This had no effect on the citrate concentration in the kidney, examined 1 hr. after the injection, although the blood-levels of lactate and pyruvate at this time were of the same order as those found at a similar time after the injection of adenosinetriphosphate[5]. Although the adenosinetriphosphate effect could not be reproduced by injection of adrenaline, adenosinetriphosphate did not cause any increase in the citrate-level in the kidney when given to rats deprived of their adrenal medullæ (see table). Since the carbohydrate stores of the body are not mobilized in adenosinetriphosphate shock in the medullectomized rat, it would seem that the block in metabolism is only evident when large amounts of carbohydrate are passing through the metabolic cycle.

We think that these results may help to elucidate the mechanism of adenosinetriphosphate shock and, perhaps, of other forms as well; although striking changes in the concentration of citrate in the kidney have not, as yet, been found in tourniquet shock in rats.

Our thanks are due to the Medical Research Council for defraying the expenses of this investigation.

C. J. Threlfall
H. B. Stoner
H. N. Green

Department of Pathology,
University of Sheffield.
April 20.

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[5] Stoner, H. B., Green, H. N., and Threlfall, C. J. (in preparation).

Isolation of Octadecan-1 : 18-diol from Spanish Broom

An examination of the non-saponifiable fraction of the absolute from Spanish broom (*Spartium junceum* L.) by chromatography on alumina has led to the isolation of a fraction which is retained tenaciously by the adsorbent. The fraction was recovered by extraction of the alumina with hot ethanol. Purification readily gave octadecan-1 : 18-diol, melting point 99° (found: C, 75·5; H, 13·2; active H, 0·6; calc. for $C_{18}H_{38}O_2$: C, 75·5; H, 13·3; active H, 0·7 per cent). Octadecan-1 : 18-diol, melting point 99°, was synthesized by the reduction of diethyl octadecan-1 : 18-dioate with lithium aluminium hydride[1], and a comparison of the synthetic and natural diols and of the corresponding diacetates and *bis*dinitrobenzoates established their identity. Confirmation of the nature of the natural product was obtained by its oxidation with chromic acid, which gave octadecan-1 : 18-dioic acid.

A number of higher straight-chain aliphatic compounds in which the terminal carbon atoms carry functional groups have been isolated from natural sources. Several long-chain αω-dicarboxylic acids have been obtained from Japan wax[2], and sabinic acid (12-hydroxylauric acid) and juniperic acid (16-hydroxypalmitic acid) have been isolated from conifer waxes[3]. The natural occurrence of long-chain aliphatic αω-diols has not previously been reported.

O. C. Musgrave
James Stark
F. S. Spring

Royal Technical College,
Glasgow.
May 9.

[1] cf. Chuit and Hausser, *Helv. Chim. Acta*, **12**, 850 (1929).
[2] Tsujimoto, *Bull. Chem. Soc. Japan*, **6**, 325 (1931). Flaschenträger and Halle, *Z. physiol. Chem.*, **190**, 120 (1930). Shinna, *J. Soc. Chem. Indust. Japan*, **43**, 173 (1940).
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Ultra-violet Absorption of Reduced Phosphomolybdate

Estimation of phosphate with molybdate in the presence of a reducing agent is a well-established colorimetric method. Using excess of phosphomolybdate, reducing substances can also be estimated. This method was used by Briggs[1] for hydroquinone and by Neuberger[2] for homogentisic acid.

We have sought a quantitative micro method for the estimation of homogentisic acid. With Neuberger's method, the blue colour given by the small amounts handled was too faint to permit accurate estimation. However, these solutions were found to have a much higher absorption in the ultra-violet region. This is illustrated in Fig. 1, showing the absorption curve (*a*) for a solution (4 ml.) containing the following: homogentisic acid (50 μgm.); potassium dihydrogen phosphate (0·3 ml. 1 per cent) and ammonium molybdate (0·3 ml. of 5 per cent in 5 *N* sulphuric acid). Measurements were carried out in 1-cm. quartz cells in a Unicam spectrophotometer, Model *S.P.*500, and solutions were allowed to stand for one hour before measurement. The curve shows a maximum at 355 mμ, and absorptions measured at this wave-length were proportional to the quantity of homogentisic acid, as shown in Fig. 2 (curve *a*).

This method has been used successfully for the estimation of 20–50 μgm. homogentisic acid in urines, after chromatography on paper and extraction of the separated homogentisic acid[3]. No doubt the method is applicable to other substances which will reduce phosphomolybdate, provided that the oxidation

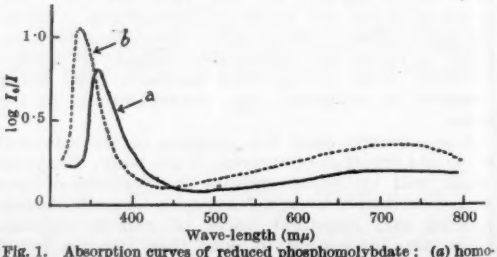

Fig. 1. Absorption curves of reduced phosphomolybdate: (*a*) homogentisic acid (50 μgm.) + phosphate + molybdate (total vol., 4 ml.); (*b*) Potassium dihydrogen phosphate (40 μgm.) + hydroquinone or ascorbic acid + molybdate (total vol., 4 ml.).

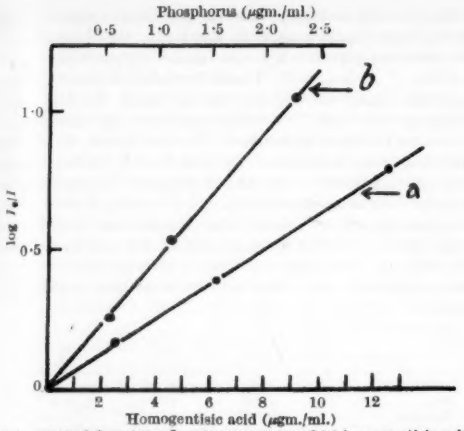

Fig. 2. Optical densities of various amounts of (*a*) homogentisic acid, measured at 355 mμ; (*b*) phosphate, measured at 335 mμ

products have negligible absorptions at 355 mμ. This is true for the oxidation product of homogentisic acid, *p*-benzoquinone-2-acetic acid[3]. Absorptions were also measured of a solution containing phosphate and excess of molybdate and a reducing agent. The latter was either hydroquinone or ascorbic acid; neither these nor their oxidation products have appreciable absorptions in the region of the observed maximum. Fig. 1 shows the curve (*b*) for a solution (4 ml.) containing potassium dihydrogen phosphate (40 μgm.), ammonium molybdate (0·3 ml. of 5 per cent in 5 *N* sulphuric acid) and hydroquinone or ascorbic acid (0·3 ml. of 1 per cent in water). The curve was identical with either reducing agent. It will be seen that the absorption is again higher in the ultra-violet; but the maximum (335 mμ) is different from that of the homogentisic acid curve.

Measurements at this and lower wave-lengths necessitated rather large slit-widths for the control reagent solutions; but above 320 mμ, absorptions could be measured without decreasing the sensitivity. Absorptions at 335 mμ were proportional to the amount of phosphate (Fig. 2, curve *b*).

R. Consden
Winifred M. Stanier
Canadian Red Cross Hospital,
Taplow,
Maidenhead.
April 10.

[1] Briggs, A. P., *J. Biol. Chem.*, **51**, 451 (1922).
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Application of the Dische Diphenylamine Reaction to Pyrimidine Deoxynucleosides

The Dische diphenylamine reaction[1], which is specific for 2-deoxysugars[2], is not suitable for the estimation of pyrimidine deoxynucleosides[3,4] because of the incompleteness of colour development.

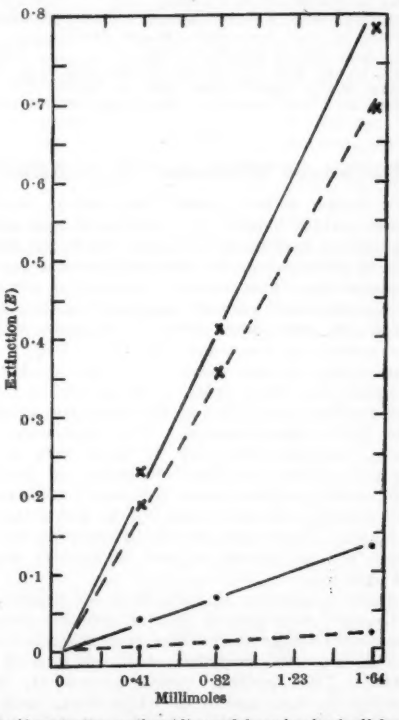
If, however, thymidine and deoxycytidine are given a preliminary treatment with bromine, there is a marked increase in colour development with thymidine, and a lesser increase with deoxycytidine.

As usually applied, the reactants in the diphenylamine test are heated in a water-bath for ten minutes or less. By extending the heating time to thirty minutes, there is no increase in colour intensity with either deoxyinosine or thymonucleic acid. As the colour development with brominated thymidine is more gradual than with purine deoxynucleosides, it is necessary, in the following experiments, to make comparisons after heating for thirty minutes.

Bromination is, with minor modifications, effected by the method of Massart and Hoste[5]. 2 ml. of the deoxynucleoside solution is heated with 0·01 ml. of bromine for five minutes in a boiling water-bath. Excess bromine is removed by aeration, and 4 ml. of the diphenylamine reagent is then immediately added.

The accompanying figure gives the extinctions at 600 mμ obtained with equimolar solutions of brominated and untreated thymidine and deoxyinosine. Bromination causes a strong development of colour with thymidine, bringing it to a value approaching that of deoxyinosine. This is strong confirmatory evidence[2] for the assumption that there is a 2-deoxysugar residue in thymidine. Bromination of deoxyinosine under identical conditions leads to a complete suppression of colour development. This is consistent with the known lability of purine deoxyribosides in acid solutions.

A commercial sample of thymonucleic acid (from which the nucleosides used in this investigation were isolated) gives an extinction which shows that not only the purine deoxynucleosides, but also a portion of the pyrimidine deoxynucleosides fail to react with the diphenylamine reagent after treatment with



Effect of bromination on thymidine and deoxyinosine in diphenylamine reaction.
— — × — — ×, Brominated thymidine; —— ● —— ●, thymidine; — — ● — — ●, brominated deoxyinosine; —— × —— ×, deoxyinosine

bromine. In contrast to this marked effect with diphenylamine, the total nucleoside concentration of such a sample of thymonucleic acid, when determined by the Mejbaum orcinol reaction[6], is only decreased by about 9 per cent. On the other hand, the free deoxynucleosides, with the exception of thymidine, do not develop any colour in the orcinol reaction after bromination.

It appears from these results that bromination causes a cleavage of the glycoside-N linkages of both purine and pyrimidine deoxynucleosides in thymonucleic acid. Further degradation of the deoxysugar is prevented by the phosphate attachments in position 3 or 5, which are not disrupted, as there is no release of organic phosphorus.

The fact that a proportion of the pyrimidine deoxynucleoside residues in thymonucleic acid fail to react with diphenylamine after bromination is evidence that the glycosidic attachment is less stable in these than in the isolated deoxynucleosides, and indicates that the C_1 of the deoxysugar of some of the pyrimidines in depolymerized thymonucleic acid are also engaged in "two distinct types of linkage (*a*) a form of polymeric linkage and (*b*) a glycofuranosidic attachment to the pyrimidine bases", as postulated for the deoxynucleosides of sperm deoxyribonucleic acid by Stacey and Overend[7].

T. G. Brady
E. McEvoy-Bowe

Department of Biochemistry,
University College,
Dublin. April 4.

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Dutch-type White-spotting in Rabbits

The Dutch rabbit usually featured in books on domestic rabbit keeping is a parti-coloured animal; the posterior half being coloured, while the anterior is largely white except for the ears and two eye circles of coloured fur. This pattern, however, is not stable. The characteristic pattern ranges from almost complete white (with blue eyes) to animals with odd white marks on the muzzle and fore-feet[1,2].

The extremely low grades of Dutch spotting are represented by small areas of white fur on the toes of the forefeet and point of the nose, the remainder of the body being normal. The expression varies from an unpigmented claw or small tuft of white hairs to a white stocking on either or both feet. White-spotting of this nature frequently occurs among rabbit stocks, and it is desirable to know the probable cause. I have been able to observe the incidence of such a case among a herd of rabbits kept for meat and fur.

A buck possessing an inch or so of white on the left forefoot was mated to five females devoid of white marks so far as could be seen macroscopically. 100 offspring were recorded as 59 self and 41 white spotted. The spotting varied somewhat, from a white toe to two inches of white foot, or a small white nose-tip to a thin streak extending up the forehead. The simplest explanation is that the male is heterozygous for a gene inducing the spotting, and the data do not conflict with the suggestion ($\chi_1^2 = 3{\cdot}24$, $P = 0{\cdot}1$–$0{\cdot}05$). Seven females from the self group were backcrossed to the buck, yielding 42 self: 35 white-spotted. By the same hypothesis, $\chi_1^2 = 0{\cdot}4608$, $P = 0{\cdot}5$–$0{\cdot}3$. Three females of the F_1 white-spotted class were also backcrossed to the male, yielding 11 self: 16 white-spotted as previously: 6 more extensively marked. In the latter, the white-spotting was expressed as almost all-white forefeet and an inverted *V* on the forehead. Assuming the segregation of a single gene, $\chi_1^2 = 1{\cdot}848$, $P = 0{\cdot}5$–$0{\cdot}3$. Combining the F_1 and first backcross, we have a total of 177, which were classified for sex as follows: 45 self ♂♂: 55 self ♀♀: 35 white-spotted ♂♂: 42 white-spotted ♀♀. An analysis of the segregation gave:

Item	χ^2	n	P
Genic	3·23	1	0·1–0·05
Sex	1·43	1	0·3–0·2
Linkage	0·02	1	0·9–0·8
	4·68	3	0·2–0·1

There is no evidence of partial sex-linkage.

The small deficiencies of white-marked animals may plausibly be attributed to weak expressibility or lack of penetrance of the white-spotting gene. No sign of heterochromia iridis was noted in any animal, but this is scarcely surprising since the condition is not usually manifested except in high-grade Dutch. It is possible that the gene described is comparable to Castle's *du*^{d} or Punnett's *s* or *t*.

Roy Robinson

St. Stephen's Road Nurseries,
Ealing, London, W.13.
March 31.

[1] Castle, W. E., Car. Inst. Wash. Pub., **288** (1919).
[2] Punnett, R. C., and Pease, M. S., *J. Genet.*, **15**, 373 (1925).

Mygalomorph Spider in Samoa

Mygalomorph spiders are notoriously absent from oceanic islands, owing to the fact that their young do not habitually distribute themselves by sailing in the air on gossamer. It is interesting, therefore, to record the occurrence in Samoa of *Idioctis helva* L. Koch, one of the Barychelidæ. This species was recorded previously only from Fiji, and the Samoan specimens differ only in minor details from the descriptions of the Fijian ones. Mygalomorph spiders of any kind are recorded in the south-west Pacific only from New Zealand, Fiji, New Caledonia and the groups to the north. All these islands are situated in the relatively shallower part of the ocean. Mygalomorphs have not previously been recorded on the truly oceanic islands to the east.

Specimens of *Idioctis helva* were collected at two widely separated localities on the island of Upolu, in Western Samoa, and also on a minute uninhabited islet between Upolu and Savaii. From this distribution it seems unlikely that it was introduced at a recent date. It inhabits a short, tough, silken tube, provided with a trap-door, and all the specimens were found within a few feet of high-water mark. All were on rocks; but if they also inhabit tree trunks they would be in a position to be transported across the sea on floating timber or on canoes. Human traffic between Fiji and Samoa cannot have a very

long history, so, if Fijian and Samoan specimens of *Idioctis* are really distinguishable, a longer separation of the two populations and consequently natural colonization would be indicated.

Two recent visits to Samoa devoted to collecting arachnids have yielded a number of spiders belonging to families not previously recorded in the Pacific, in spite of the fact that Samoa is one of the best-known localities so far as spiders are concerned. Members of the Palpigradi and Schizomida were also obtained, and these orders do not appear to have been noticed before in the area. Evidently considerable intensive collecting must be done before much can be deduced from the geographical distribution of the more obscure invertebrate groups such as the arachnids.

B. J. MARPLES

Department of Zoology,
University of Otago,
The Museum, King Street,
Dunedin.
March 14.

Marsilea spp.: Materials for the Experimental Study of Morphogenesis

DURING recent years, improvements in the methods of sterile culture of organs and tissues have provided a valuable means of assessing the importance in morphogenesis of the various plant nutrients. It has been found that species of the heterosporous fern *Marsilea* grow well in sterile culture and show a sensitive response to changes in composition of the culture medium.

Sterile cultures are easily prepared from the resistant sporocarps, which, after treatment with absolute alcohol and bromine water, are washed once and opened in sterile water. Fertilization occurs overnight, and on the following day the young embryos may be transferred to tubes of the culture medium.

Much better growth is obtained in liquid culture than on agar media. The basic inorganic medium is a Knop's solution, supplemented by Berthelot's solution, as recommended by Gautheret[1]. The cultures are maintained at approximately 21° C., with a fairly low light intensity (100 foot-candles) which avoids any appearance of etiolation, but is inadequate for growth unless a suitable organic supply is present in the medium. Of the sugars investigated, sucrose supports the best growth, but adequate growth is also obtained with glucose or fructose. No other organic constituents are necessary, and in a medium containing sugar good growth continues even in complete darkness.

Fig. 1 illustrates a culture of *M. drummondii* A.Br. after five months of growth in a medium containing 5 per cent sucrose. Passing from the base towards the apex of the plant it will be noticed there is a gradual alteration in leaf form. The first acicular leaf (not shown) is followed by a spatulate leaf, then by bifid leaves, which in turn are succeeded by dorsiventral leaves, each with a quadrifid lamina, until finally the radially symmetrical 'four-leaf clover' type of the mature plant is obtained. Changes in the sugar concentration of the medium have a pronounced effect on this leaf succession and indeed on the entire morphology of the plant. Fuller details will be published elsewhere; but it may be indicated here that these effects are in part nutritional and in part osmotic. In this connexion, transfer experiments have yielded interesting results.

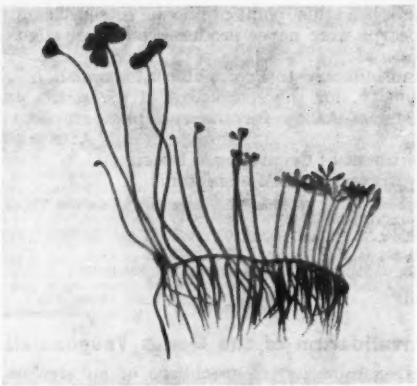

Fig. 1. *M. drummondii* after five months on medium containing 5 per cent sucrose. (Nat. size)

Isolated terminal growing points also grow well in the liquid medium: they afford excellent material for the investigation of the relation between nutrition and morphogenesis. Lateral growing points, one at the base of each leaf, begin active growth when the rhizome is divided up into separate nodes. The type of leaf produced by the laterals in part depends on the number of nodes from the base of the plant, and also on the previous nutritional history.

The sterile culture of pteridophytes is no new development[2]; but previous workers have not recorded the production of sporangia by their sporophytic plants. In the present work, which has been primarily concerned with the early stages of development, sporocarps were never obtained in cultures of *M. drummondii*. In *M. vestita* Hook and Grev., however, several plants produced sporocarps when cultured in a medium containing 5 per cent sucrose. The apical region of one of these plants is illustrated in Fig. 2. The sporocarps are quite normal in appearance; but since a dormant period is required, they have not yet been tested for viability. In Nature, strong light favours the formation of sporocarps, which are rarely produced on submerged plants[3,4]. It would seem from the present work that a high sugar concentration can take the place of the strong light normally required. Further work will be required

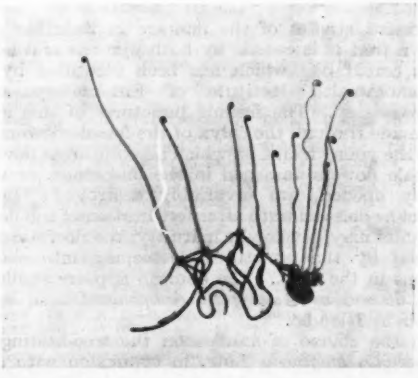

Fig. 2. *M. vestita*, after five months on medium containing 5 per cent sucrose. Apical region only. Some roots removed to reveal sporocarp. (Nat. size)

to establish this point; but it is significant that sporocarps were never produced on lower sugar concentrations.

I am indebted to Prof. Gilbert M. Smith, Stanford University, for the sporocarps of *M. vestita* and to Mr. Ernest Ashby for the two photographs.

A. Allsopp

Department of Cryptogamic Botany,
University of Manchester.

[1] Gautheret, R. J., "Manual Technique de Culture des Tissus Végétaux" (Paris, 1942).
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Invalidation of the Genus *Vaughaniella*

An examination of specimens of an alga at first assigned to *Vaughaniella rupicola* Boergs. has led to the conclusion that the genus *Vaughaniella* Boergs.[1] represents the basal rhizomatous portion of the genus *Padina* Adans. In southern Queensland, these flattened rhizomes, often showing transition to fan-shaped thalli, are found at the base of plants of *Padina commersonii* Bory in both estuarine and exposed localities; but around the margins of shallow lower littoral pools, on exposed rock platforms, rhizome development may sometimes take place without any production of fan thalli.

A more complete account will be published elsewhere.

A. B. Cribb

Fisheries Research Laboratory,
Commonwealth Scientific and Industrial
Research Organization,
Cronulla, N.S.W.

[1] Boergesen, F., *Kon. Danske Vidensk. Selsk., Biol. Medd.*, **15**, (8) (1950).

An Insect Pest of Coconuts and its Relationship to Certain Ant Species

In 1924 McDonald[1] and Welsford[2,3] reported the presence in Kenya, Tanganyika and Zanzibar of widespread damage of coconut fruits characterized by abortion of young female flowers, excessive dropping of young nuts and formation of necrotic lesions in those nuts which reached maturity. The damage was attributed to unfavourable soil conditions.

Present studies of the damage in Zanzibar have shown that it is caused by both nymphs and adults of a coreid bug which has been identified by the Commonwealth Institute of Entomology as a *Theraptus* sp. The feeding punctures of this insect are made through the calyx of the female flowers and into the young fruits, on which necrotic areas develop. Female flowers damaged in the bud stage, or when newly opened, are invariably destroyed; but if attack is delayed until after fertilization of the flower, the nuts may develop to maturity, the necrotic areas caused by the punctures developing into slit-like lesions in the husk. The damage appears similar to that caused by *Amblypelta cocophaga* China, in the Solomon Islands[4].

In the course of studies on the tree-nesting ant *Oecophylla longinoda* Latr. in connexion with clove diseases, it was noticed that damage by *Theraptus* sp. was absent or negligible in coconut palms occupied by this ant. The ant has been observed destroying *Theraptus* sp. nymphs on coconut palms, and it probably destroys or deters the adults. It is of interest that an *Oecophylla* species was apparently used as a beneficial predator on citrus pests in China so far back as the twelfth century[5]; and in the Far East, Simmonds[6], Tothill[7] and Murray[8] have reported that *O. smaragdina* is predatory on several coconut pests.

Details of the yield of nuts from a single gathering in a block of fifty-two coconut palms, of which sixteen were inhabited by *O. longinoda*, are shown in Table 1. The figures for yields shown in the table are approximately one-quarter of the annual yields.

Table 1

	No. of nuts/tree	Percentage nuts showing lesions caused by *Theraptus* sp.	
		0–10 lesions/nut	More than 10 lesions/nut
O. longinoda present	21·2	16·5	6·2
O. longinoda absent	4·9	48·6	50·3

The figures show that, in the absence of *O. longinoda*, not only is the yield of nuts greatly reduced by *Theraptus* sp. attack, but also damage to the nuts obtained is practically 100 per cent. Such damage results in reduction in size of nut and in yield of copra, as shown in Table 2.

Table 2

	Approximate No. of lesions/nut			
	None	0–10	10–20	>20
Wt. (lb.) of 100 unhusked nuts	286	264	229½	164
Wt. (lb.) of copra from above 100 nuts	47½	45½	36½	25½

Certain ground-nesting but tree-foraging ants, notably *Anoplolepis longipes* Jerd. and *Pheidole megacephala* F., ssp. *punctulata* Mayr., have replaced *O. longinoda* in many coconut areas of Zanzibar. The figures for coconut yields which have been obtained show that *Theraptus* sp. damage is not significantly reduced by the presence of the above two ant species. Observations on these ants in coconut palms show that they are not aggressive towards *Theraptus* sp.

Studies are in progress on the ecology of the various ant species with the object of determining conditions under which *O. longinoda* will replace the non-beneficial ants. Results of these and of studies of the problem on the coasts of Kenya and Tanganyika, as well as work on insecticidal control of *Theraptus* sp., will be reported later.

M. J. Way

Clove Research Scheme,
Zanzibar.
(Seconded from
Rothamsted Experimental Station,
Harpenden, Herts.)
March 27.

[1] McDonald, J., Ann. Rep. Kenya Dept. Agric., 106 (1924).
[2] Welsford, E. J., Ann. Rep. Dept. Agric., Zanzibar, 15 (1924).
[3] Welsford, E. J., Tech. Conf., E. African Dependencies, Nairobi, 205 (1926).
[4] Phillips, J. S., *Bull. Ent. Res.*, **31**, 295 (1940).
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[6] Simmonds, H. W., Fiji Dept. Agric., Bull. 16 (1925).
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FORTHCOMING EVENT

Tuesday, August 21—Friday, August 24

BRITISH INSTITUTION OF RADIO ENGINEERS (at King's College, Cambridge).—Radio Convention, Session 5: Television Engineering.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

DEMONSTRATOR IN BACTERIOLOGY—The Secretary, University College Hospital Medical School, University Street, London, W.C.1 (August 25).

EDUCATIONAL PSYCHOLOGIST—The Director of Education, 5 Portland Square, Carlisle (August 25).

HEAD OF THE DEPARTMENT OF ENGINEERING, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham—The Chief Education Officer, County Offices, Chelmsford (August 25).

MECHANICAL and ELECTRICAL ENGINEERS in the Works Department of the Air Ministry in connexion with the design, operation and maintenance of ground mechanical and electrical works services on R.A.F. stations at home and overseas and on civil aviation stations—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.19/48A (Grade I) or D.370/50A (Grade II) (August 25).

LECTURER IN CHEMISTRY—The Principal, Wigan and District Mining and Technical College, Wigan (August 27).

ASSISTANT LECTURER (with a degree in zoology and botany) IN BIOLOGY—The Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1 (August 31).

CHEMIST in the Insecticides and Fungicides Section at Long Ashton Research Station, for work on the separation and characterization of the components of tar distillates—The Registrar and Secretary, The University, Bristol 8 (August 31).

PHYSICAL CHEMIST (Scientific Officer or Senior Scientific Officer grade) for work on boiler corrosion, with experience in high temperature corrosion (Ref. F.495/51A), a PHYSICAL CHEMIST (Scientific Officer or Senior Scientific Officer grade) for work on soil corrosion, with experience and qualifications in electrochemistry (Ref. F.496/51A), MICROBIOLOGISTS (2, Scientific Officer grade) for work on sulphate-reducing bacteria (Ref. G.255/51A), a PHYSICAL CHEMIST (Experimental Officer grade) for work on boiler corrosion, with experience in research on surface reactions (Ref. F.497/51A), a MICROBIOLOGIST (Experimental Officer grade) for curation of culture collection (Ref. G.256/51A), and MICROBIOLOGISTS (3, Experimental Officer or Assistant Experimental Officer grade) for work on sulphate-reducing bacteria (Ref. G.257/51A), at the Chemical Research Laboratory, Teddington—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (August 31).

RESEARCH WORKER to take part in a programme of research in regeneration and tissue culture—The Secretary, University College, Gower Street, London, W.C.1 (September 7).

ASSISTANT LECTURER IN METALLURGY in the Department of Coal Gas and Fuel Industries—The Registrar, The University, Leeds 2 (September 10).

ENGINEERS I at a Ministry of Supply establishment at Sevenoaks, with experience appropriate to (*a*) development of optical instruments, including optical processing, and of drives for ultra high-speed cameras (Ref. C.461/51A), (*b*) development of radio communications and monitoring equipment (Ref. D.343–4/51A)—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (September 14).

INSTRUMENT AND RADIO PRODUCTION ENGINEERS in the Ministry of Supply in London, with extensive knowledge of airborne radio equipment, radio navigational aids, test and measuring equipment, lightweight and miniaturized electronic airborne equipment, quartz crystals, engine flight and navigational instruments, gyroscopic instruments, electric lamps—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.338/51A (September 14).

LECTURER IN THE DEPARTMENT OF NATURAL PHILOSOPHY—The Secretary, The University, Edinburgh (September 15).

NUFFIELD RESEARCH FELLOWSHIP in the Wheatstone Physics Laboratory—Prof. J. T. Randall, F.R.S., King's College, Strand, London, W.C.2 (September 15).

LECTURER IN PHYSIOLOGY (Cow and Gate Research Fellow)—The Dean, Institute of Child Health, Hospital for Sick Children, Great Ormond Street, London, W.C.1 (September 30).

VICE-CHANCELLOR OF THE UNIVERSITY OF NEW ZEALAND—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 15).

SENIOR LECTURER or LECTURER IN BOTANY at the University of Natal, Pietermaritzburg and Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 31).

ASSISTANT CHIEF MECHANICAL ENGINEER to assist the Chief Mechanical Engineer in the general administration of the Mechanical Engineering Section of the Public Works Department, Sudan—The Sudan Government Office, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Assistant C.M.E.4/123'.

INSECTICIDE CHEMIST in the West African Cacao Research Institute—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting 27106/39.

PHYSICISTS to supervise and undertake research work involving the application of physical methods to the study of metals and the control of new metallurgical processes—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

PLANT PATHOLOGIST in the Agricultural Department, Tanganyika—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting 27059/277.

PRODUCTION CHEMISTS for Royal Ordnance Factories in Irvine, Bishopton, Chorley, Swynnerton, Glascoed, Pembrey, Bridgwater and in headquarters, London, to assist in technical control of administration of explosives and acids manufacture or ammunition filling, including development work—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.542/51A.

PROFESSORS (2) and ASSOCIATE PROFESSORS (2) IN THE FACULTY OF ELECTRICAL ENGINEERING at the Technion (Institute of Technology), Haifa, Israel—The Secretary, The Technion Society of Great Britain, 13 Mansfield Street, London, W.1.

RESEARCH ASSISTANT (with appropriate honours degree or equivalent) to take part in studies mostly concerned with the use of chicks in nutritional research—The Secretary, National Institute for Research in Dairying, Shinfield, Berks., quoting Ref. 51/5.

TECHNICAL ENGINEER to undertake fundamental technical work in the application of engineering principles to the design of nuclear reactors and allied atomic energy projects, and to predict the performance of such plants—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

REPORTS and other PUBLICATIONS

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National Health Service Act, 1946. Central Health Services Council. Report of the Central Health Services Council for the Year ending December 31, 1950, preceded by a Statement made by the Minister of Health. Pp. viii+48. (London: H.M. Stationery Office, 1951.) 1*s.* 6*d.* net. [56

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British Standard 577: 1951. Hexachloroethane. Pp. 12. 2*s.* net. British Standard 579: 1951, Technical Ether. Pp. 10. 2*s.* net. (London: British Standards Institution, 1951.) [66

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Department of Agriculture for Scotland. The Shepherd's Guide to the Prevention and Control of the Diseases of the Sheep. Compiled by Dr. J. Russell Greig. Pp. 108+4 plates. (Edinburgh and London: H.M. Stationery Office, 1951.) 3*s.* net. [66

Empire Cotton Growing Corporation. Progress Reports from Experimental Stations, Season 1949–1950. Pp. ii+140. (London: Empire Cotton Growing Corporation, 1951.) 3*s.* [76

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Medical Research Council. Memorandum No. 11: The Control of Cross Infection in Hospitals. Revised edition. Pp. 49. (London: H.M. Stationery Office, 1951.) 1*s.* 9*d.* net. [196

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British Museum (Natural History). Economic Series No. 12: The Cockroach; its Life-History and How to Deal with It. Fifth edition. Pp. iv+26. (London: British Museum (Natural History), 1951.) 9*d.* [196

International Committee for Bird Preservation, British Section. Annual Report for 1950. Pp. 48+4 plates. (London: International Committee for Bird Preservation, c/o British Museum (Natural History), 1951.) 2*s.* [196

Agricultural Research Council. Report Series No. 10: The Wood Pigeon in Britain. By M. K. Colquhoun. Pp. vi+69. (London: H.M. Stationery Office, 1951.) 3*s.* net. [196

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Royal Institute of Chemistry. Lectures, Monographs and Reports 1951, No. 1: Statistical Methods with Special Reference to Analytical Chemistry. By D. R. Read. Pp. 46. (London: Royal Institute of Chemistry, 1951.) 4*s.* 6*d.* net. [206

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